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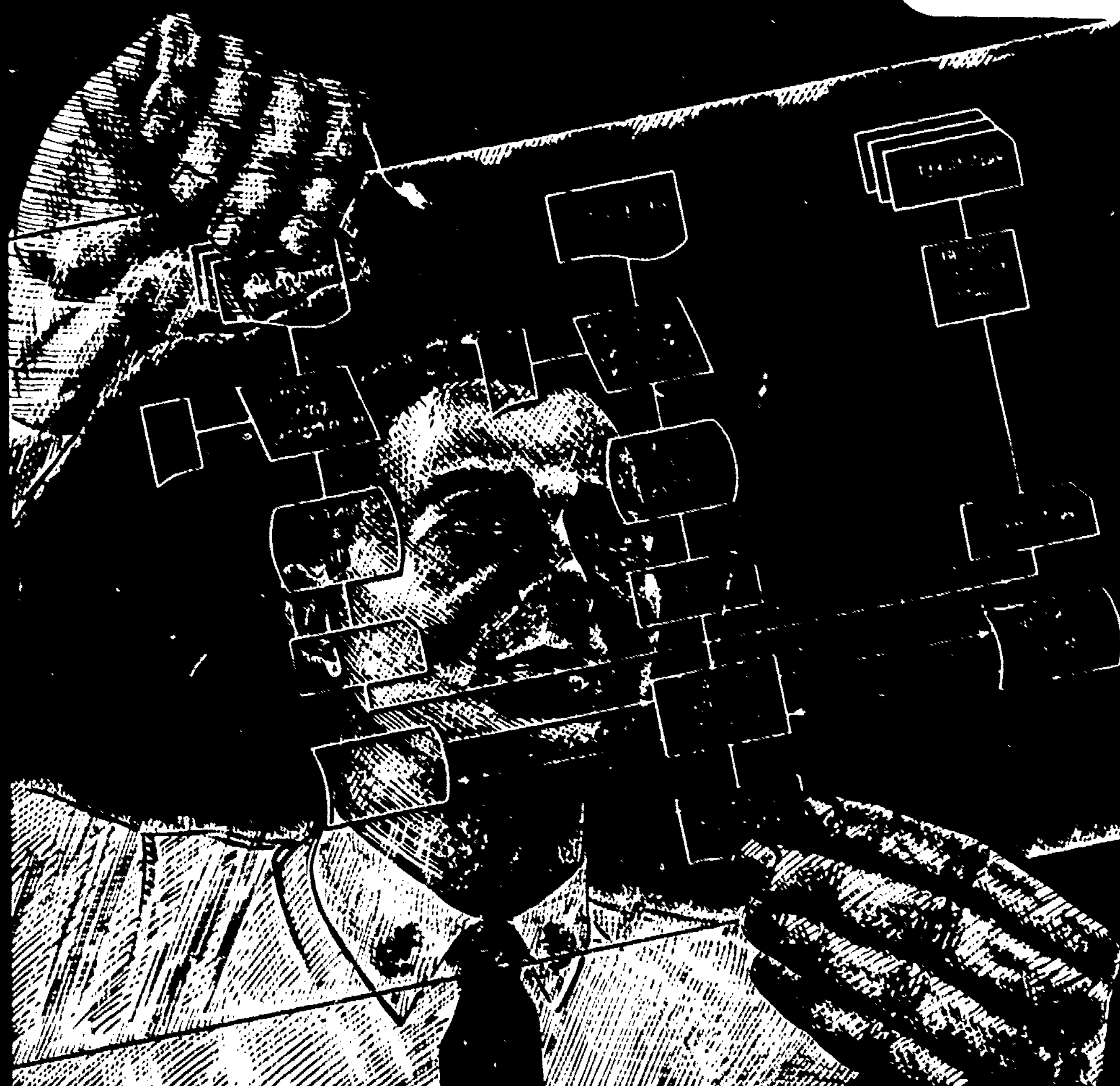
ABSTRACT

The contents of this training manual are divided into eight chapters. Chapter 1 provides introductory information. Chapter 2 presents the principles of programming which includes the basic concepts necessary for preparing for a programming course. Systems analysis--fact finding and critical examination of the facts--and approaches to systems design--deciding what general plan will be followed in design are covered in Chapter 3. The procedures discussed in Chapter 4 deal with the conduct of systems studies generally leading to the selection, acquisition, and employment of an Automatic Data Processing (ADP) system. The techniques and methods discussed in Chapter 5 are to be considered immediately before the installation of a new ADP system. Chapter 6 discussed procedure development which consists of: documentation, flowcharting, preparation of office manuals, and card and form design. The supervisory controls discussed in Chapter 7 pertain to data control, operations control, and control of magnetic tape and program libraries. Chapter 8 covers data processing management procedures. A subject index is appended. (Author/NH)



DATA PROCESSING TECHNICIAN 1&C

BUREAU OF NAVAL PERSONNEL

RATE TRAINING MANUAL NAVPERS 10265-B

PREFACE

This book is intended to serve as an aid for personnel who are seeking to acquire the theoretical knowledge and the operational skills required of candidates for advancement to the rate of Data Processing Technician First Class or Chief Data Processing Technician. As one of the Navy training manuals, this book was prepared by the Training Publications Division, Naval Personnel Program Support Activity, Washington, D.C., for the Bureau of Naval Personnel. Review and technical assistance were provided by the U.S. Naval Examining Center, Great Lakes, Ill.; Personnel Accounting Machine Installation, Continental United States, Bainbridge, Md.; the Service School Command, Naval Training Center, San Diego, Calif.; Fleet Computer Programming Center, Pacific, San Diego, Calif.; and by the Bureau of Naval Personnel.

First Edition 1964
(Entitled Machine Accountant 1/C)

Major Revision 1967
Major Revision 1970

Stock Ordering No.
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THE UNITED STATES NAVY

GUARDIAN OF OUR COUNTRY

The United States Navy is responsible for maintaining control of the sea and is a ready force on watch at home and overseas, capable of strong action to preserve the peace or of instant offensive action to win in war.

It is upon the maintenance of this control that our country's glorious future depends; the United States Navy exists to make it so.

WE SERVE WITH HONOR

Tradition, valor, and victory are the Navy's heritage from the past. To these may be added dedication, discipline, and vigilance as the watchwords of the present and the future.

At home or on distant stations we serve with pride, confident in the respect of our country, our shipmates, and our families.

Our responsibilities sober us; our adversities strengthen us.

Service to God and Country is our special privilege. We serve with honor.

THE FUTURE OF THE NAVY

The Navy will always employ new weapons, new techniques, and greater power to protect and defend the United States on the sea, under the sea, and in the air.

Now and in the future, control of the sea gives the United States her greatest advantage for the maintenance of peace and for victory in war.

Mobility, surprise, dispersal, and offensive power are the keynotes of the new Navy. The roots of the Navy lie in a strong belief in the future, in continued dedication to our tasks, and in reflection on our heritage from the past.

Never have our opportunities and our responsibilities been greater.

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CREDITS

Preparation of this manual was aided by the cooperation and courtesy of International Business Machines Corporation, C-E-I-R, Institute for Advanced Technology, and Radio Corporation of America. These companies furnished the technical manuals which aided considerably in the preparation of this text. Permission to use these manuals in assembling the material contained herein is gratefully acknowledged.

Illustrations not listed below are from Navy sources.

SOURCE	FIGURES
IBM	2-7, 2-8, 5-1, 5-2, 5-3, 5-4, 5-5, 5-6, 5-7, 5-8, 5-9, 5-10, 5-11, 6-1, 6-2, 6-3, 6-4, 6-5, 7-1, 7-2, 7-3, 7-4, 7-5, 7-6, 8-2, 8-3.
RCA	3-1, 3-2, 3-3, 3-4, 3-5, 3-6, 3-8, 3-9, 4-1, 4-2.
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CHAPTER 1

ADVANCEMENT

This rate training manual is designed to help you meet the occupational qualifications for advancement to Data Processing Technician First Class and Chief Data Processing Technician. Chapters 2 through 8 of this manual deal with the technical subject matter of the Data Processing Technician rating. The present chapter provides introductory information that will help you in working for advancement. It is strongly recommended that you study this chapter carefully before beginning intensive study of the chapters that follow.

REWARDS AND RESPONSIBILITIES

Advancement brings both increased rewards and increased responsibilities. The time to start looking ahead and considering the rewards and the responsibilities is right now, while you are preparing for advancement to DP1 or DPC.

By this time, you are probably well aware of many of the advantages of advancement—higher pay, greater prestige, more interesting and challenging work, and the satisfaction of getting ahead in your chosen career. By this time, also, you have probably discovered that one of the most enduring rewards of advancement is the personal satisfaction you find in developing your skills and increasing your knowledge.

The Navy also benefits by your advancement. Highly trained personnel are essential to the functioning of the Navy. By each advancement you increase your value to the Navy in two ways. First, you become more valuable as a technical specialist in your own rating. And second, you become more valuable as a person who can supervise, lead, and train others and thus make far reaching and long lasting contributions to the Navy.

In large measure, the extent of your contribution to the Navy depends upon your willingness and ability to accept increasing responsibilities as you advance. When you assumed the duties of a DP3, you began to accept a certain amount of responsibility for the work of others. With each advancement, you accept an increasing responsibility in military matters and in matters relating to the occupational requirements of the Data Processing Technician rating.

You will find that your responsibilities for military leadership are about the same as those of petty officers in other ratings, since every petty officer is a military person as well as a technical specialist. Your responsibilities for technical leadership are special to your rating and are directly related to the nature of your work. Data processing in today's Navy is a job of vital importance and it's a teamwork job; it requires a special kind of leadership ability that can only be developed by personnel who have a high degree of technical competence and a deep sense of personal responsibility.

Certain practical details that relate to your responsibilities for personnel administration, supervision, and training are discussed in later chapters of this training course. At this point, let's consider some of the broader aspects of your increasing responsibilities for military and technical leadership.

<u>Your responsibilities will extend both upward and downward.</u> Both officers and enlisted personnel will expect you to translate the general orders given by officers into detailed, practical on-the-job language that can be understood and followed even by relatively inexperienced personnel. In dealing with your juniors, it is up to you to see that they perform their work properly. At the same time, you must be able to explain to officers any important needs or problems of the enlisted men.

<u>You will have regular and continuing responsibilities for training.</u> Even if you are lucky enough to have highly skilled and well trained personnel, you will still find that training is necessary. Also, some of your best workers may be transferred and inexperienced or poorly trained personnel may be assigned to you. Or a particular job may call for skills that none of your personnel have. These and similar problems require you to be a training specialist who can conduct formal and informal training programs to qualify personnel for advancement and who can train individuals and

groups in the effective execution of assigned tasks.

You will have increasing responsibilities for working with others. As you advance to DP1 and then to DPC, you will find that many of your plans and decisions affect a large number of people, some of whom are not in the division and some of whom are not even in the activity. It becomes increasingly important, therefore, to understand the duties and responsibilities of personnel in other ratings. Every petty officer in the Navy is a technical specialist in his own field. Learn as much as you can about the work of other ratings, and plan your own work so that it will fit in with the overall mission of the organization.

As your responsibilities increase, your ability to communicate clearly and effectively must also increase. The basic requirement for effective communication is a knowledge of your own language. Use correct language in speaking and in writing. Remember that the basic purpose of all communication is understanding. To lead, supervise, and train others, you must be able to speak and write in such a way that others can understand exactly what you mean.

A second requirement for effective communication in the Navy is a sound knowledge of the Navy way of saying things. Some Navy terms have been standardized for the purpose of ensuring efficient communication. When a situation calls for the use of standard Navy terminology, use it.

Still another requirement of effective communication is precision in the use of technical terms. A command of the technical language of the Data Processing Technician rating will enable you to receive and convey information accurately and to exchange ideas with others. A person who does not understand the precise meaning of terms used in connection with the work of his own rating is at a disadvantage when he tries to read official publications relating to his work. He is also at a great disadvantage when he takes the written examinations for advancement. Although it is always important for you to use technical terms correctly, it is particularly important when you are dealing with lower rated men; sloppiness in the use of technical terms is likely to be very confusing to an inexperienced man.

You will have increased responsibilities for keeping up with new developments. Practically everything in the Navy—policies, procedures, equipment, publications, systems—is subject to change and development. As a DP1, and even more as a DPC, you must keep yourself informed about all changes and new developments that might affect your rating or your work.

Some changes will be called directly to your attention, but others you will have to look for. Try to develop a special kind of alertness for new information. Keep up to date on all available sources of technical information. And, above all, keep an open mind on the subject of data processing and associated equipment. New types of data processing equipment are constantly being designed and tested, and existing types of data processing equipment are subject to modification. If you look back over the history of data processing since the end of World War II, you will find that a tremendous number of important changes have occurred during this time. Continuing developments in electronics and solid state physics led to newer and better components.

The vacuum tube was replaced by a smaller semiconductor diode that has the advantage of demanding less power. A further advance came when tiny transistors were introduced in place of vacuum tubes in the computer. Not only can these transistors be packed into smaller units, but they have greater reliability. The changeover to transistors was accomplished, creating what has frequently been referred to as the "Second Generation" of computer.

The next technological advance miniaturized and refined components of the Second Generation. This, when done, led to a concept known as Solid Logic Technology. The use of these components ushered in the "Third Generation" of computer.

These changes are by no means the only ones that have occurred during this period of time; they are noted here merely to indicate the variety of changes that can be expected in the field of data processing and associated equipment.

Research scientists have already advanced to still further stages in design. Some are studying the use of microwave phenomena as a medium for performing computer logic. Others are studying the behavior of materials and electrons at extremely low temperatures (cryogenics).

THE DATA PROCESSING TECHNICIAN RATING

Personnel of the Data Processing Technician rating perform a great number of functions associated with data processing support programs through the use of many types of automatic data processing equipment. They gather and process source information, and produce reports and other services in accordance with Navy managerial requirements. They are thoroughly familiar with data processing applications, including, in the higher paygrades, applications of general purpose digital computers, programming, systems analysis, participation in designing automatic data processing systems, and administrative and management functions peculiar to data processing offices and installations.

Automatic data processing in the Navy evolved from the early days of World War II with the urgent demands of the Chief of Naval Personnel to handle the increased clerical workload. As a result, BUPERS installed and began using punched card data processing equipment, resulting in the establishment of the Specialist (I) rating. This rating remained a specialist rating until 1948. At that time it was designated Machine Accountant (MA) and incorporated into the Regular Navy rating structure. On July 1, 1967, it was redesignated Data Processing Technician, a more descriptive and appropriate title for the rating.

Data Processing Technicians may be ordered to many different types of activities which perform data processing by both electrical and electronic methods. These include ship and shore installations of the Operating Forces, Shore Support activities, Bureaus, Systems Commands, and Offices of the Navy Department. Generally speaking, the mission of a data processing installation is prescribed by the Bureau, Office, or Systems Command exercising command. The data processing systems employed may be broadly grouped as personnel, supply, maintenance material management (3M), fiscal, research, security, communications, and operations control. An installation may perform data processing services under one or more of these systems, and various other miscellaneous services, depending upon the type of installation and its assigned mission.

A limited number of particularly well qualified Data Processing Technicians are given assignments to instruct in Navy schools; to assist in making up the servicewide advancement in rating examinations at the Naval Examining Center, Great Lakes; to assist in the preparation of rate training manuals and other training materials in the Training Publications Division, Naval Personnel Program Support Activity, Washington; and to perform other highly specialized duties where their technical knowledge can be utilized effectively. (This training manual that you are now studying was revised by a Chief Data Processing Technician while he was assigned to an instructor billet at Training Publications Division.) Regardless of location, all Data Processing Technicians are assigned by the Bureau of Naval Personnel, Washington, D.C.

REQUIREMENTS FOR ADVANCEMENT

In general, to qualify for advancement you must:

1. Have a certain amount of time in grade.
2. Complete the required military and occupational training courses.
3. Demonstrate the ability to perform all the PRACTICAL requirements for advancement by completing the Record of Practical Factors, NavPers 1414/1 (formerly NavPers 760).
4. Be recommended by your commanding officer.
5. Demonstrate your KNOWLEDGE by passing a written examination based on (a) the military requirements for advancement and (b) the occupational qualifications for advancement in the Data Processing Technician rating.

FINAL MULTIPLE

Advancement is not automatic. Meeting all the requirements makes you eligible for advancement but does not guarantee your advancement. The number of men in each rate and rating is controlled on a Navy-wide basis. Therefore, the number of men that may be advanced is limited by the number of vacancies that exist. When the number of men passing the examination exceeds the number of vacancies, a system must be used to determine which men may be advanced and which may not. The system used is the "final multiple" and is a combination of three types of advancement systems.

Merit rating system
Personnel testing system
Longevity, or seniority system

The Navy's system provides credit for performance, knowledge, and seniority, and, while it cannot guarantee that any one person will be advanced, it does guarantee that all men within a particular rating will have equal advancement opportunity.

The following factors are considered in computing the final multiple:

Factor	Maximum Credit
Examination score	80
Performance factor (Performance evaluation)	50
Length of service (years x 1)	20
Service in pay grade (years x 2)	20
Medals and awards	15
	185

All of the above information (except the examination score) is submitted to the Naval Examining Center with your examination answer sheet. After grading, the examination scores, for those passing, are added to the other factors to arrive at the final multiple. A precedence list, which is based on final multiples, is then prepared for each pay grade within each rating. Advancement authorizations are then issued, beginning at the top of the list, for the number of men needed to fill the existing vacancies.

KEEPING CURRENT ON ADVANCEMENT

Remember that the requirements for advancement may change from time to time. Check with your division officer or with your training officer to be sure you have the most recent requirements when you are preparing for advancement and when you are helping lower rated men to prepare.

To prepare for advancement, you need to be familiar with (1) the military requirements and the occupational qualifications given in the Manual of Qualifications for Advancement, NavPers 18068-B (with changes); (2) the Record of Practical Factors, NavPers 1414/1; (3) appropriate rate training manuals; and (4) any other material that may be required or recommended in the current edition of Training Publications for Advancement, NavPers 10052. These materials are discussed later in the section of this chapter that deals with sources of information.

SCOPE OF THIS TRAINING MANUAL

What you should gain from your study of this training manual is detailed in the following statements concerning its purpose and scope:

- It is designed to give you information on the occupational qualifications for advancement to DP1 and DPC.
- It must be satisfactorily completed before you can advance to DP1 or DPC, whether you are in the Regular Navy or in the Naval Reserve.
- It is NOT designed to give you information on the military requirements for advancement to PO1 or CPO. Rate training manuals that are specially prepared to give information on the military requirements are discussed in the section of this chapter that deals with sources of information.
- It is NOT designed to give information that is related primarily to the qualifications for advancement to DP3 and DP2. Such information is given in Data Processing Technician 3 & 2, NavPers 10264-B.
- The occupational Data Processing Technician qualifications that were used as a guide in the preparation of this training manual were those promulgated in the Manual of Qualifications for Advancement, NavPers 18068-B, change 5. Therefore, changes in the Data Processing Technician qualifications occurring after this change may not be reflected in the information given in this training manual. Since your major purpose in studying this manual is to meet the qualifications for advancement to DP1 or DPC, it is important for you to obtain and study a set of the most recent Data Processing Technician qualifications.
- This training manual includes information that is related to both the KNOWLEDGE FACTORS and the PRACTICAL FACTORS of the qualifications for advancement to DP1 and DPC. However, no training manual can take the place of actual on-the-job experience for developing skill in the practical factors. The manual can help you understand some of the whys and wherefores, but you must combine knowledge with practical experience before you can develop the required skills. The Record of Practical Factors, NavPers 1414/1, should be utilized in conjunction with this training manual whenever possible.
- This training manual deals almost entirely with data processing systems and associated equipment and techniques. It does NOT contain information that is primarily related to a particular system.
- Chapters 2 through 8 of this training manual, as already stated, deal with the occupational subject matter of the Data Processing Technician rating. Before studying these

chapters, study the table of contents and note the arrangement of information. Information can be organized and presented in many different ways. You will find it helpful to get an overall view of the organization of this training manual before you start to study it.

SOURCES OF INFORMATION

It is very important for you to have an extensive knowledge of the references to consult for detailed, authoritative, up-to-date information on all subjects related to the military requirements and to the occupational qualifications of the Data Processing Technician rating.

Some of the publications discussed here are subject to change or revision from time to time—some at regular intervals, others as the need arises. When using any publication that is subject to change or revision, be sure you have the latest edition. When using any publication that is kept current by means of changes, be sure you have a copy in which all official changes have been entered.

BUPERS PUBLICATIONS

The BuPers publications described here include some which are absolutely essential for anyone seeking advancement and some which, although not essential, are extremely helpful.

THE QUALS MANUAL.—The Manual of Qualifications for Advancement, NavPers 18068-B (with changes), gives the minimum requirements for advancement to each rate within each rating. The Quals Manual lists the military requirements which apply to all ratings and the occupational qualifications that are specific to each rating.

The Quals Manual is kept current by means of numbered changes. These changes are issued more frequently than most rate training manuals can be revised; therefore, the training manuals cannot always reflect the latest qualifications for advancement. When preparing for advancement, you should always check the LATEST Quals Manual and the LATEST changes to be sure that you know the current requirements for advancement in your rating.

When studying the qualifications for advancement, remember these three things:

1. The quals are the MINIMUM requirements for advancement to each rate within each rating. If you study more than the required minimum, you will of course have a great advantage when you take the written examination for advancement.

2. Each qual has a designated pay grade—E-4, E-5, E-6, E-7, E-8, or E-9. You are responsible for meeting all quals specified for advancement to the pay grade to which you are seeking advancement AND all quals specified for lower pay grades.

3. The written examinations for advancement to E-6 and above contain questions relating to the practical factors and the knowledge of BOTH military/leadership requirements and occupational qualifications. Personnel preparing for advancement to E-4 or E-5 must pass a separate military/leadership examination prior to participation in the Navy-wide occupational examination. The military/leadership examinations for the E-4 and E-5 levels are given according to a schedule prescribed by the commanding officer. Candidates are required to pass the applicable military/leadership examination only once.

A special form known as the RECORD OF PRACTICAL FACTORS, NavPers 1414/1, is used to record the satisfactory completion of the practical factors, both military and occupational, listed in the Quals Manual. This form is available for each rating. Whenever a person demonstrates his ability to perform a practical factor, appropriate entries must be made in the DATE and INITIALS column. As a DP1 or DPC, you will often be required to check the practical factor performance of lower rated men and to report the results to your supervising officer. To facilitate record keeping, groups records of practical factors are often maintained aboard ship. Entries from the group records must, of course, be transferred to each individual's Record of Practical Factors at appropriate intervals.

As changes are made periodically to the Quals Manual, new forms of NavPers 1414/1 are provided when necessary. Extra space is allowed on the Record of Practical Factors for entering additional practical factors as they are published in changes to the Quals Manual. The Record of Practical Factors also provides space for recording demonstrated proficiency in skills which are within the gener[illegible] of the rating but which are not identifi[illegible]mum qualifications for advancement. Keep [illegible]is in mind when you are training and supervising lower rated personnel. If a man demonstrates proficiency in some skill which is not listed in the DP quals but which falls within the general scope of the rating, report this fact to the supervising officer so that an appropriate entry can be made.

The Record of Practical Factors should be kept in each man's service record and should be forwarded with the service record to the next duty station. Each man should also keep a copy of the record for his own use.

NAVPERS 10052.—Training Publications for Advancement, NavPers 10052, is a very important publication for anyone preparing for advancement. This publication lists required and recommended rate training manuals and other reference material to be used by personnel working for advancement. NavPers 10052 is revised and issued once each year by the Bureau of Naval Personnel. Each revised edition is identified by a letter following the NavPers number. When using this publication, be SURE you have the most recent edition.

The required and recommended references are listed by rate level in NavPers 10052. It is important to remember that you are responsible for all references at lower rate levels, as well as those listed for the rate to which you are seeking advancement.

Rate training manuals that are marked with an asterisk (*) in NavPers 10052 are MANDATORY at the indicated rate levels. A mandatory training manual may be completed by: (1) passing the appropriate enlisted correspondence course based on the mandatory manual, (2) passing locally prepared tests based on the information given in the mandatory manual, or (3) in some cases, successfully completing an appropriate Navy school.

It is important to notice that all references, whether mandatory or recommended, listed in NavPers 10052 may be used as source material for the written examinations, at the appropriate rate levels.

RATE TRAINING MANUALS.—Rate training manuals are written for the specific purpose of helping personnel prepare for advancement. Some courses are general in nature and are intended for use by more than one rating. Others (such as this one) are specific to the particular rating.

Rate training manuals are revised from time to time to bring them up to date. The revision of a rate training manual is identified by a letter following the NavPers number. You can tell whether a training manual is the latest edition by checking the NavPers number and the letter following the number in the most recent edition of the List of Training Manuals and Correspondence Courses, NavPers 10061 (revised).

Each time a rate training manual is revised, it is brought into conformance with the official publications and directives on which it is based, but during the life of any edition, discrepancies between the manual and the official sources are almost sure to arise because of changes to the latter which are issued in the interim. In the performance of your duties, you should always refer to the appropriate official publication or directive. If the official source is listed in NavPers 10052 and is therefore a source used by the Naval Examining Center in preparing the advancement examinations, the Examining Center will resolve any discrepancy of material by using that which is most recent.

There are three rate training manuals that are specially prepared to present information on the military requirements for advancement. They are:

Basic Military Requirements, NavPers 10054
Military Requirements for Petty Officer 3 & 2, NavPers 10056
Military Requirements for Petty Officer 1 & C, NavPers 10057

Each of the military requirements manuals is mandatory at the indicated rate levels. In addition to giving information on the military requirements, these three books give a good deal of useful information on the enlisted rating structure; how to prepare for advancement; how to supervise, train, and lead other men; and how to meet your increasing responsibilities as you advance.

Some of the rate training manuals that may be useful to you when you are preparing to meet the occupational qualifications for advancement to DP1 and DPC are discussed briefly in the following paragraphs. For a complete listing of rate training manuals, consult the List of Training Manuals and Correspondence Courses, NavPers 10061 (revised).

Mathematics, Vol. 1, NavPers 10069-B, and Mathematics, Vol. 2, NavPers 10071-A. These two training manuals may be helpful if you need to brush up on your mathematics. Volume 1, in particular, contains basic information that is needed for using formulas and for making simple computations. The information contained in volume 2 is more advanced and you may occasionally find it helpful.

Digital Computer Basics, NavPers 10088. Although this training manual is not specifically required for advancement in the Data Processing Technician rating, you will find that it contains a good deal of useful information that may be of value to you as you prepare for advancement to DP1 and DPC.

Data Processing Technician 3 & 2, NavPers 10264-B. Satisfactory completion of this training manual is required for advancement to DP3 and DP2. If you have met this requirement by satisfactorily completing an earlier edition of this manual (Machine Accountant 3 & 2), you should at least glance through the -B revision of the manual. Much of the information given in this edition of Data Processing Technician 1 & C is based on the assumption that you are familiar with the contents of Data Processing Technician 3 & 2, NavPers 10264-B.

CORRESPONDENCE COURSES.—Most rate training manuals and officer texts are used as the basis for correspondence courses. Completion of a mandatory training course can be accomplished by passing the correspondence course that is based on the training manual. You will find it helpful to take other correspondence courses, as well as those that are based on mandatory training manuals. For example, the completion of the correspondence course based on Naval Orientation is strongly recommended for personnel preparing for advancement to DPC. Taking a correspondence course helps you to master the information given in the training manual or text and also gives you a pretty good idea of how much you have learned from studying the book.

OTHER BUPERS PUBLICATIONS.—Additional BuPers publications that you may find useful in connection with your responsibilities for leadership, supervision, and training include the Manual for Navy Instructors, NavPers 16103-C and the Naval Training Bulletin, NavPers 14900 (published quarterly).

TECHNICAL MANUALS

The manufacturers' technical manuals that are available for most automatic data processing systems are valuable sources of information. These manuals cover in detail the areas covered broadly in the rate training manuals.

TRAINING FILMS

Training films available to naval personnel are a valuable source of supplementary information on many technical subjects. Films that may be of interest are listed in the United States Film Catalog, NavWeps 10-1-777, published in 1966. This catalog is now listed in the NavSup Forms and Publications Catalog, NavSup 2—2, as NavAir 10-1-777. Beginning in 1967, Supplements to the Film Catalog carry the number 10-1-777.

When selecting a film, note its date of issue listed in the film catalog. As you know, procedures sometimes change rapidly. Thus some films become obsolete rapidly. If a film is obsolete only in part, it may sometimes be shown effectively if before or during its showing you carefully point out to trainees the procedures that have changed. For this reason if you are showing a film to train other personnel, take a look at it in advance if possible so that you may spot material that may have become obsolete and verify current procedures by looking them up in the appropriate sources before the formal showing.

CHAPTER 2
PRINCIPLES OF PROGRAMMING

A computer must be provided with a set of instructions before it can carry out any data processing function. An automatic data processing (hereafter called ADP) system is capable of performing a complete data processing routine automatically from start to finish ONLY if supplied with the necessary detailed instructions for performing each and every step required in the routine. An ADP system is an excellent follower, not a leader; it will do exactly what it is told, no more and no less.

It is not the intent of this chapter to make a programmer out of anyone—that in itself requires books and formal training. Each computer system has its own particular set of instructions which it is capable of recognizing and executing. It can be seen by the great number of names of programming languages shown in figure 2-1 that almost every computer has a programming system specifically adapted for its own use and that it would be impossible for one person to be familiar with them all. This is beyond our capabilities, so we must set our sights on goals which are more realistic. The intent, however, is that, with the principles presented here, the reader may be able to learn the basic concepts and better prepare for a programming course.

BASIC COMPUTER INSTRUCTIONS

Data processing is a series of planned actions and operations upon information to achieve a desired result. The procedures and devices used constitute a data processing system. The devices may vary: all operations may be done by machine, or the devices may be only pencil and paper. The procedures, however, remain basically the same.

There are many types of ADP systems. These vary in size, complexity, cost, levels of programming systems, and application. But, regardless of the information to be processed or the equipment used, all ADP involves at least three basic considerations:

1. The source data or input entering the system.
2. The orderly, planned processing within the system.
3. The end result or output from the system.

Input may consist of any type of data: commercial, scientific, statistical, engineering, and so on.

After data is transcribed to an input medium, the computer system can take over the complete processing and the preparation of results. However, the procedural steps that are to take place within the computer system must be defined precisely in terms of operations that the system can perform. Each step must be written as an INSTRUCTION to the computer.

A series of instructions pertaining to an entire procedure is called a PROGRAM. In modern ADP systems, the program is stored internally, and the system has access to the instructions at electronic speeds. Such programs are called STORED PROGRAMS.

Program instructions, when written, consist of symbols which may be numbers, letters of the alphabet, or special characters, and when stored internally, tell the computer what to do, how, and when each specific operation is to be performed. An instruction usually consists of at least two parts:

1. OPERATION CODE.—The operation code of an instruction designates to the computer what function or operation is to be performed, such as read, write, add, subtract, compare, move data, etc.

2. OPERAND.—The operand normally contains the address of the data that is needed for the specified operation. The operand portion of the instruction word may be the number to be used in a calculation; it may be the address in memory of the number to be used; it may indicate the number of operations to be performed, i.e., left shift the contents of a register x places, repeat the next instruction x times; or it may

AAS	COLASL	IPS	SAAL
ACT	COMPACT	IT	SAC
ACUTE	COMPASS	ITL V	SAIC
ADAPT	CS-1	JOVIAL	SAL
AIMACO	CT	KINGSTRAN	SALT
ALCOM	DANTRAN	LANGLEY	SAP
ALGOL	DAP	LASS	SCAT
ALGP	DAS	LEAP	SCOPAC
ALMOST	DATACODE	LIST	SCRAP
ALTAC	EASY	MACHINE LANGUAGE	SEACOM
ALTRAN	EASY CODER	MACRO	SEASAP
APT	ESCAPE	MAD	SHARE
ARGUS	FACT	MADCAP	SLAP
ART	FAP	MAP	SNOBOL
AS-1	FARGO	METASYMBOL	SOAP
ASAP	FAST	MISHAP	SOS
ASSEMBLER	FCP	MONARCH	SPACE
AUTOCODE	FLIP	NAPS	SPAR
AUTOCODER	FLIT	NEAT	SPEED
AUTOCOM	FLOCO	NELIAC	SPS
BAP	FLOWMATIC	NOBAS	SPURT
BASIC ASSEMBLER	FORAST	NUCOM	STAR
BEFAP	FORCOM	NYAP	STRAP
BELL	FORGO	ORBIT	SURGE
BEST	FORMOST	OPAL	SYMBO
BLESSED	FORTOGO	OSAP	SYMBOL
CAGE	FORTRAN	OSAS	TABSOL
CALINT	FORTRAN L	PAL	TAC
CAP	FORTRAN II	PAP	TASK
CASE SOAP	FORTRAN IV	PINT	TASS
CAT-C4	FORTRAN 63	PL-1	TIMA
CL1	FORTRAN 400	POGO	TOPS
CL2	FORTRANSIT	PROCOM	TRANSUSE
CLIP	GAP	PSEUDO	UNISAP
CLMTRAN	GECOM	RAFT IV	USE
COBOL	GP	RELCODE	UTMOST
COBOL 60	GPX	RIP 3000	VFAP
COBOL 61	IBMAP	ROAR	WIZ
COBOL NARRATOR	INTERCOM	RPG	WIZOR
CODAP	INTERFOR	S4	XMAS

78.115

Figure 2-1.—Partial list of the names of computer programming languages.

be the address into which data will be placed, or from which it will be moved. Or it may be the address of the next instruction to be performed as in a branch or conditional branch instruction.

Some computers operate with instruction word lengths which can vary from word to word and are called variable word length computers. Others use fixed word lengths wherein information is handled and addressed in units or words containing a predetermined number of positions. The size of a word is designed into the system.

SINGLE AND MULTIPLE ADDRESS INSTRUCTION FORMAT

The instruction format of a computer word may contain more than one operand. Generally a single-address computer is one in which each instruction word references a single address in memory. A single-address instruction format is shown in figure 2-2. This type of computer begins its operation at the first or some specified instruction in the program and continues by taking instruction words one at a time from memory in sequence unless interrupted by a halt or branch instruction.

OPERATION CODE	ADDRESS *(or operand)*

78.116

Figure 2-2.—Single-address instruction word.

For example, "ADD THE CONTENTS OF ADDRESS A TO THE ACCUMULATOR," is a single-address instruction because only one memory address is referenced (address A). A variation of the single-address instruction is a "replace ADD" instruction, which may read "ADD THE CONTENTS OF ADDRESS A TO THE ACCUMULATOR AND REPLACE IN A." Again only one address is referenced.

A two-address instruction word is shown in figure 2-3. As the name implies, the word consists of a single operation code and the two addresses (A and B) which are included in the operations. An instruction for this type of computer may read "ADD THE CONTENTS OF ADDRESS A TO THE CONTENTS OF ADDRESS B." Here, two addresses are referenced by a single instruction. The "replace ADD" instruction may also be used such as, "ADD THE CONTENTS OF ADDRESS A TO THE CONTENTS OF ADDRESS B AND REPLACE IN ADDRESS A."

The two-address instruction word is sometimes used as illustrated in figure 2-4. The instruction specifies only one address involved in the computer operations, this word is sometimes called a one and one-half address word

OPERATION CODE	ADDRESS A	ADDRESS B

124.255

Figure 2-3.—Two-address instruction word.

OPERATION CODE	ADDRESS A	ADDRESS OF NEXT INSTRUCTION

124.256

Figure 2-4.—Variation of two-address instruction word.

to distinguish it from the conventional two-address word.

The three-address instruction word (figure 2-5) generally contains the operation code, two addresses (A and B) and an address C for storing the results of the operation performed on the information from the A and B addresses.

The four-address word (figure 2-6) contains the operation code, two data addresses (A and B), address C for storage, and the fourth address which is the address of the next instruction to be performed.

The number of addresses in each instruction word is a design feature. Instruction words containing more than four addresses do not seem practicable at this time.

BASIC TYPES OF INSTRUCTIONS

A computer instruction is a command to carry out a specific data processing function. It is this ability to process instructions that provides the almost unlimited flexibility and the so-called logical ability of the stored program system. Most instructions can be grouped according to the specific type of operation to be performed. The basic types of instructions can be grouped into one of the following broad classifications:

- Input/output instructions
- Data transfer instructions
- Arithmetic instructions
- Decision making instructions
- Miscellaneous instructions

INPUT/OUTPUT INSTRUCTIONS

Input/output instructions are the commands which control the operation of the peripheral

OPERATION CODE	ADDRESS A	ADDRESS B	ADDRESS C (for storing the result of A modified by B).

124.257(78B)

Figure 2-5.—Three-address instruction word.

OPERATION CODE	ADDRESS A	ADDRESS B	ADDRESS C FOR STORAGE OF RESULTS	ADDRESS D NEXT INSTRUCTION

124.258

Figure 2-6.—Four-address instruction word.

equipments (any unit of equipment, distinct from the Central Processing Unit, which provides the system with outside communication). Some of the specific types of I/O instructions are:

- Read or punch a card
- Write or print a line
- Read or write tape
- Carriage control, advance paper, skip, etc.

Card feeding from the computer card readers and punches is performed only when specific read and punch instructions in the stored program are executed. Magnetic tape is fed only on command by a tape read or write instruction. Likewise, the printer takes a print cycle only when instructed to do so by the program.

DATA TRANSFER INSTRUCTIONS

Data transfer instructions are used primarily to move or transmit data INTERNALLY from one location in memory to another. Computers must have storage areas assigned for incoming records and processing. Otherwise, the system has no way of knowing where to store the data it has read, where to get the information it is to process, etc. These areas are specified in one of two ways; by wired circuitry in the system, or by stored instructions. Data transfer instructions direct the system to MOVE data from the input area to the output area, or cause data in one area to transfer to another storage area as specified by the instruction. Specific types of internal data transmission instructions are:

- Move or transmit data
- Move or transmit field
- Move or transmit character, zones, etc.

Movement of data from one area to another does not generally destroy the original data. It merely duplicates it in another area in memory.

ARITHMETIC INSTRUCTIONS

- Add
- Subtract
- Multiply
- Divide
- Clear and add, etc.

The above are examples of arithmetic instructions. In every operation of simple arithmetic, at least two factors are involved: multiplier and multiplicand, divisor and dividend, and so on. These factors are operated on by the arithmetic unit of the machine to produce a result, such as a product or a quotient. In every calculation, therefore, at least two storage locations are needed. One quantity is usually in main storage, the other in a register or accumulator.

A calculation can be started by placing one of the factors in the register/accumulator which will at the same time clear this unit of any previous factors or results that may be contained there. The address part of the instruction specifies the storage location of one of the factors; the register containing the other factor is implied by the operation. In some computers, more than one register is available for calculation. In this case, the address must also specify the register to be used.

When one of the factors is properly placed in the accumulator or other suitable register, the actual calculation is executed by an instruction whose operation part specifies the arithmetic to be performed and whose operand is the location of the second factor. The computer acts upon two factors, one in the register and the other in storage, and produces a result in either place, as directed. The result may then be manipulated according to the programmer's instructions.

Operations of shifting and rounding the contents of the register are also provided to adjust, lengthen, or shorten results. With these operations, decimal values may be handled and directions for placing of the decimal point may be given to the computer.

All calculations must take into account the algebraic sign of factors in storage or associated registers. Consequently, the computer system is equipped with some provision to store and recognize the sign of the factor.

If records are made up of fixed words of data, one position of the word is designated as a sign position and automatically accompanies the word. Registers also include either a special sign position of storage or a sign indicator that is available to the programmer. In this way, the sign of results can be determined, together with the effect, after calculations. The computer follows the rules of algebra in all basic arithmetic calculations.

Calculations are carried out in all computer systems at much higher rates of speed than input or output, since reading, writing, punching, etc., require the use of mechanical devices, while calculation is performed electronically. The design of any particular system must achieve a realistic balance between calculating and record-handling ability.

DECISION-MAKING INSTRUCTIONS

A computer normally executes instructions in sequential order. That is, it advances from one instruction storage location to the next, interpreting and executing instructions in succession. The programmer may, however, insert various TEST and TRANSFER instructions into the program to cause the computer to take its next instruction from some other location, depending upon the condition encountered during the test. Decision-making can be thought of as a form of LOGIC, and operations performed by the execution of decision-making instructions as LOGICAL OPERATIONS. The decision-making ability of a computer is based on a comparison of one factor with another. Any comparison will reflect one of three possible results: greater than, equal to, or less than. The particular result obtained is the controlling agent which allows the computer to determine the next instruction or series of instructions to be executed. The following examples cite a few of the many decision-making instructions:

- Compare
- Unconditional branch
- Compare and branch (The results of comparison of numbers, digits, or fields are registered as high, low or equal by indicators or triggers that may then be interrogated to determine their condition. If, for example, a particular indicator is interrogated and found to be OFF, processing might continue in the normal manner. If the indicator was found to be ON, a branch (transfer, jump) instruction might cause the normal sequence of instructions to be altered, causing a transfer to a sub-routine which would process the data in a different manner.)
- Branch if last card
- Branch if word mark, flag, switch is set, etc.

MISCELLANEOUS INSTRUCTIONS

Miscellaneous instructions are used to control various functions such as clearing specific sections of memory so that the areas are blank either when processing is in progress or as it begins, controlling the printer carriage, establishing constant factors for use during the execution of the program, etc. Miscellaneous instructions include:

- Forms control
- Clear storage
- No operation
- Set word marks, flags, switches
- Clear word marks, flags, switches
- Halt

Housekeeping

The term housekeeping denotes those operations that must normally be performed in preparation for processing. Several miscellaneous instructions are used in housekeeping operations. These instructions may set program switches, clear registers, set up print areas, move constants, and so on. These instructions are not limited to housekeeping operations, but may be used at any required point in the program.

In addition, housekeeping instructions may perform systems checks by testing to determine whether all I/O units required by the program are attached to the system and ready for operation. Often information pertinent to the proper operation of the system may be called to the operator's attention by program instructions, which cause messages to be outputted onto a low-speed peripheral device such as an on-line teletypewriter.

METHODS OF ADDRESSING

In general, no particular areas of storage are reserved for the instructions only. In most instances, they are grouped together and placed, in ascending sequential locations, in the normal order in which they are to be executed by the computer. However, the order of execution may be varied by special instruction, by recognition of a predetermined condition of data or devices within the system, by hardware conditions that require servicing from a special set of programs, or by other programs that require unusual priority.

The normal sequence of computer operation in a complete program is as follows:

> The computer locates the first instruction either by looking in a predetermined location of storage assigned for this purpose or by manual reset. This first instruction is executed. The computer then locates the next instruction and executes it. This process continues automatically, instruction by instruction, until the program is completed or until the computer is directed to stop.

The only distinction between instructions and data in main storage lies in the time they are brought into the central processing unit. If information is brought in during an instruction cycle, it is interpreted as an instruction; if brought in during any other type of cycle, it is considered to be data.

The computer can operate upon its own instructions, if those instructions are supplied as data. The computer can also be programmed to alter its own instructions according to conditions encountered during the handling of a procedure.

The ability of the computer to make limited decisions on the basis of programmed logic is substantially extended by operations of comparing. Such operations enable the computer to determine whether two data fields in storage match, or whether one is lower or higher than the other. The basis of comparison is set according to some predetermined sequence built into the circuitry.

In addition to branching or transfer instructions, the program may be varied by changing or modifying the operation part of the instructions themselves. INSTRUCTION MODIFICATION, for example, can be used to set up a program switch that can cause the machine to take one of two alternate paths. The switch is turned on or off by a programmed instruction.

ADDRESS MODIFICATION

The address portion of instructions may also be treated as data. An instruction address can be modified by arithmetic, it may be compared against other addresses or factors, or relocated in storage at will. Address modification serves two purposes:

1. The total number of instructions in a program may be reduced, conserving storage capacity for data or other factors. One instruction, or a single series of instructions, can serve to address variable locations in storage.
2. A basic flow of work controlled by the program can serve as a pattern of procedure that can change as required by the entry data, the result of calculation, various error conditions, end-of-file detection, and so on.

For example, the address portion of an instruction that gets information from a table may be modified by the value of a character in a register.

INDEXING

In many computers, the address portion of an instruction can be modified by adding or subtracting variable quantities contained in one or more special purpose counters. The counter may be called an index register when it is set aside specifically for this purpose, or it may be a predetermined location in core storage called an index word. A computer may have several index registers or a number of storage locations for index words. However, both the index register and the index word perform identical functions.

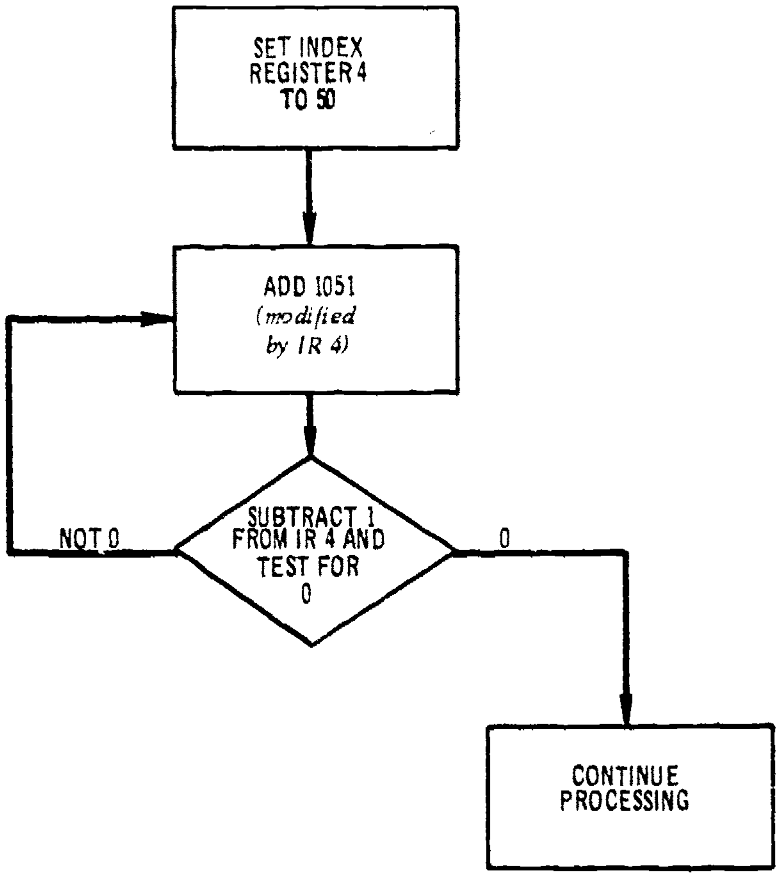
Computers with an indexing feature use an expanded instruction format that allows a particular register or word to be specified as a part of the instruction operand.

Assume that 50 quantities are placed in ascending word positions of storage from locations 1001 to 1050 inclusive and that these quantities are to be added to the contents of a register. Without indexing or address modification, it is necessary to repeat an add instruction 50 times with the address of each instruction incremented by 1, as ADD 1001, ADD 1002, ADD 1003, and so on.

With indexing, the add instruction can be written as ADD 1051, with the address decremented by an index register containing the quantity 50. The address remains 1051, but the computer calculates an effective address of 1051 minus 50, or 1001. (Note: Using a wrong count is a very common error when programming and can cause serious confusion.) When the add instruction is executed, the contents of the index register are also decremented by 1, leaving a remainder of 49. When the same add instruction is reexecuted and is again decremented by the contents of the same index register, the effective address is 1051 minus 49, or 1002. If a program loop is formed to repeat this process, the effective address of the add instruction is stepped up 1 each time it is executed (as the index register is stepped down). When the index register equals 0, all 50 quantities will have been added, and the loop is terminated. The computer consequently performed 50 operations using the same instructions.

Figure 2-7 is a flow diagram of the index loop. The first instruction places the quantity 50 in index register 4. An add instruction, with an address 1051, also specifies as part of its operand a designation that the given address is to be modified by the quantity contained in index register 4.

The next instruction is branch on index, which means: reduce the contents of the index register by 1; if the contents of the register are greater than zero, branch to repeat the add instruction; if the contents of the index register equal zero, continue to the next instruction in the program.



78.117X

Figure 2-7.—Flow diagram of index loop.

The indexing feature is a powerful programming tool, as it simplifies programming of repetitious calculations or other operations and reduces the required number of instructions.

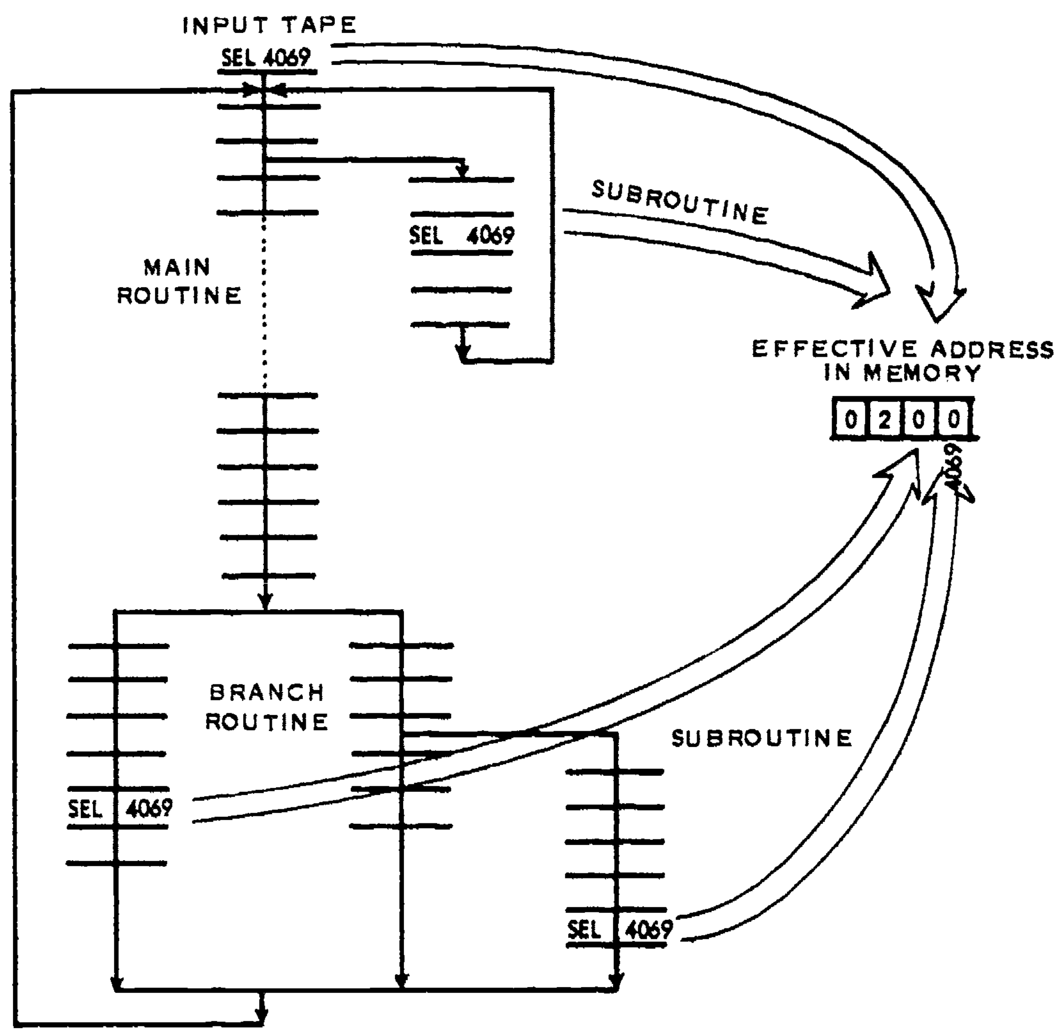
INDIRECT ADDRESSES

The instruction addresses discussed previously can be classified as direct—that is, they refer directly to the location of data or other instructions in storage, they select a machine component, or they specify the type of control to be exercised.

Addresses may also be indirect. Such an address can refer only to a storage location that contains another address. The second address, in turn, refers to the location of data, a machine component, or a control function.

Indirect addressing is particularly useful in performing address modification. For example, in a program it may be necessary to refer a number of instructions to a value that changes during the program run. Without indirect addressing, a number of modification instructions would be needed.

However, if instructions are indirectly addressed to one core storage location, that location can contain a single address: the address of the values being used by the program. Therefore, to change or to modify all instruction addresses, it is necessary only to modify the single effective address to which the instructions refer (see figure 2-8). Any number of indirect addresses throughout a program may refer to a single effective address. In figure 2-8, each indirectly addressed instruction (SEL 4069) would bring in the contents of core location 200 instead of location 4069.



78.118X

Figure 2-8.—Indirect address.

BASIC PROGRAMMING TECHNIQUES

Programs vary from a length of several hundred instructions to those containing thousands of instructions. Ultimately, the program begins to occupy a significant portion of the computer memory, perhaps even an excessive portion. One method of overcoming this problem is to segment the program, i.e., place a portion of it in auxiliary storage, and read it into main memory only when it is required. This is particularly convenient with seldom used segments. Another method is to ensure that the program is as concise as possible.

SUBROUTINES

An important method of developing this conciseness is through the use of subroutines. Obviously, as a program grows larger certain functions are repeated. If the instructions required to perform these functions are grouped they may be referenced by a relatively few instructions in the main program, thus obviating writing the instructions in the main program each time the function is performed.

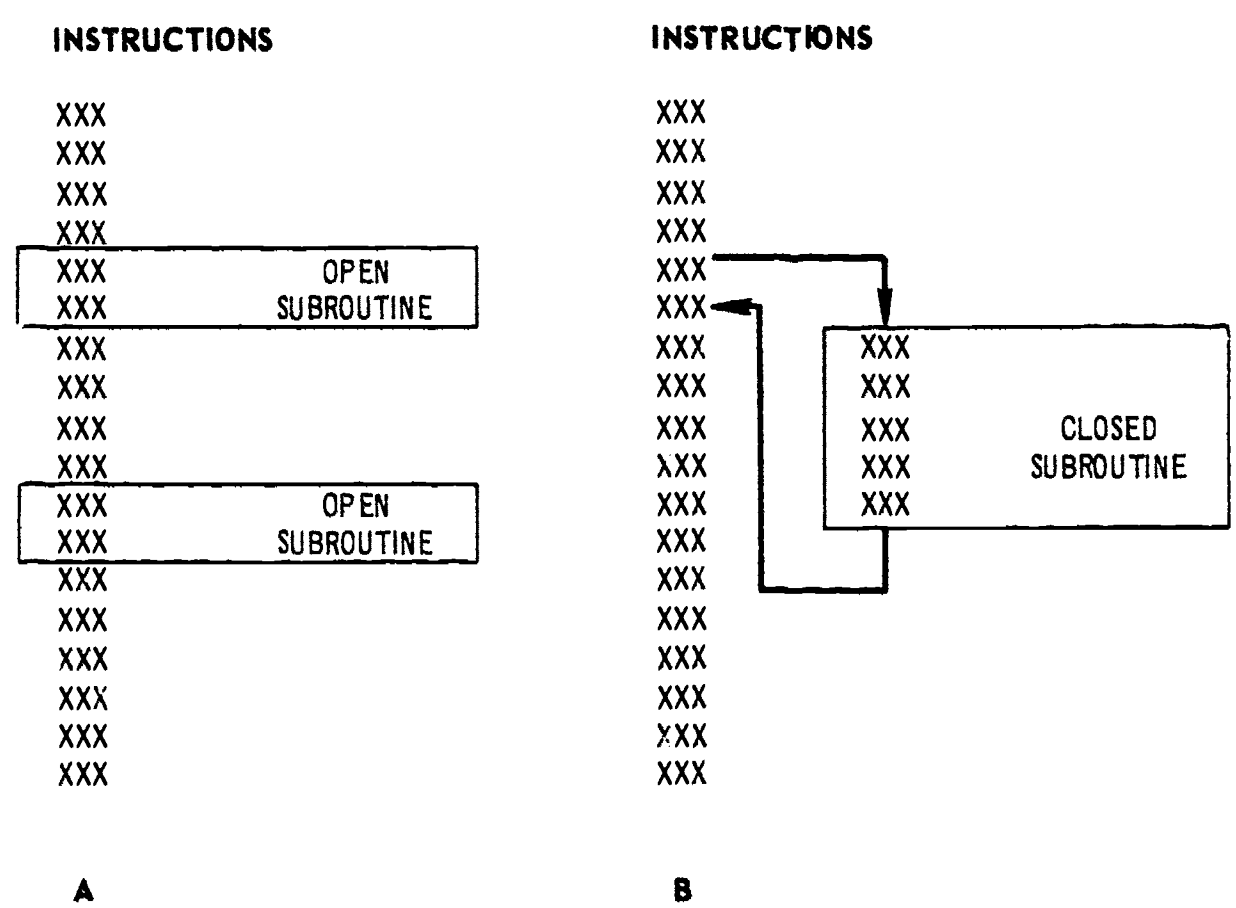
Most installations utilize a program library of subroutines for the more standardized problems encountered, such as mathematical operations involving multiplication, division, square root, etc.

Open Subroutine

A subroutine located in sequential order within the main program is called an open subroutine; that is, it is inserted in the main program where it is needed, and appears in the program as many times as needed as shown in figure 2-9A.

MACRO INSTRUCTIONS

Many of the routines that must be incorporated in programs are general in nature and can be used repeatedly with little or no alteration. A macro instruction is a single command written by the programmer that will generate an entire series of machine language instructions in the object program to perform some operation, such as arithmetic operations, input/output routines, etc.



78.119

Figure 2-9.—Open and closed subroutines.

Closed Subroutine

Assume the same subroutine is needed at several different places in the program. Inserting the subroutine in several different places requires a considerable amount of storage space. It can, instead, be placed in one storage place, apart from the main line of the program, and branch instructions may be utilized repeatedly to the subroutine when it is needed. Figure 2-9B illustrates a closed subroutine. The main program branches to it when necessary, and the subroutine branches back to the main program when it is finished.

A macro is a form of an open subroutine that relieves the programmer of much repetitive coding by enabling him to call a sequence of instructions from a library routine, and have these instructions tailored automatically by the processor to fit his particular program.

LOOPS

An important programming technique is looping, or executing a particular instruction or sequence of instructions a given number of times. The number of repetitions is determined by a fixed count placed in an index register, or as the result of a logical decision made during the execution of the group of instructions. An iterative loop must perform the following tasks:

- Initialization
- Processing
- Modification
- Termination

Initializing the loop consists of setting the various parameters which will determine the number of times the loop will be repeated and what modifications are to be made. When indexing prior to the execution of the loop, the index count must equal the desired number of executions, indexing after execution of a loop means the loop count will be one less than the desired number of executions. (This is due to the fact that one execution of the loop has occurred prior to indexing.)

Processing refers to the instructions which execute the desired function of the loop.

Modifying is not necessarily a part of a loop. When it is, it refers to the changes made to any of the instructions in the loop or any of the parameters.

Terminating a loop consists of leaving the group of instructions and continuing with some other part of the program, or the computer may be instructed to halt. The termination may be due to exhausting the index (loop count) or compliance with some TESTING applied during execution of the loop. There may be more than one exit or termination in a given loop.

PROGRAM CHECKOUT

The actual process of locating and correcting errors in a new or revised computer program is referred to as "DEBUGGING." This is done to make sure that the program does not have logical or clerical errors and that it is capable of producing the results for which it was intended.

Mistakes by the programmer are more difficult to avoid than might be expected. It is, in fact, a rare program that works correctly the first time it is tried with test data. In most cases, several test runs must be made before all mistakes are found and corrected.

Computer mistakes are rare and usually obvious. Built-in detection circuits will normally reflect the kind of mistake the computer has made by turning on an indicator and stopping the computer. Detection and classification of the mistakes a programmer can make are, however, many times more complex.

Testing Techniques

Many techniques exist to assist the programmer during the checkout phase of his work. Each has its own advantages and disadvantages. The one to be used for a particular problem will depend upon the programmer's thoughts as to what area of his program is in error and how extensive the error is. Techniques that involve extensive use of switches on the operator's console are very wasteful of computer time and are not recommended. Some of the basic techniques used in program testing and debugging are discussed in the following paragraphs.

DESK CHECKING.—Many of the clerical and logical errors which may appear in a coded program can be eliminated prior to assembling or compiling the program by first conducting an extensive manual desk check. Thorough examination should begin with the flowcharts, coding sheets and off line listings to desk process the program, step by step, from housekeeping to the end of the program.

PROGRAM LISTINGS.—The assembly or compiling process automatically produces a program listing, if desired. A program listing usually contains a complete list of the original symbolic instructions along with the machine language instructions and the memory allocations of the instructions. In addition, these assembly and compiling systems are frequently designed to edit the program for format errors, invalid operation codes, undefined tags or labels, and other miscellaneous checks.

TEST DATA.—After the program has been successfully assembled or compiled, the programmer should prepare test data in the form used by the program to force the program to execute every instruction. Test data need not be large in volume, but should contain every possible condition, whether or not the condition represents a legitimate occurrence. Live data may be modified to meet these requirements.

MEMORY DUMP.—This type of utility program (routine) is helpful because the contents of storage, plus the contents of registers and the condition of indicators and switches may be presented in printed form. The dump routine normally has provisions for dumping one or more selected blocks of storage instead of all of it. This method can be used to great advantage when a program halts during a test run.

TRACE ROUTINES.—The trace routine is an invaluable aid to debugging when the program difficulty is known to exist but cannot be isolated by examining the memory dump. The trace technique is a routine that monitors a program as it is being run, and executes a number of instructions for each program instruction being traced. The printout received while tracing any selected address or group of addresses normally includes the location of the instruction being executed, the instruction being executed, and the contents of the working registers after the instruction has been executed.

With this method, a "snapshot" is obtained of a particular part of the program under particular conditions. Extensive trace routines can be time consuming and should be used with caution.

PROGRAMMING SYSTEMS

Machine language coding refers to the use of machine language in the preparation of the computer instructions by the programmer. Such coding is sometimes referred to as actual or absolute coding. Machine language coding was the only method of programming available before assembler and compiler systems were developed for computers.

Some of the more significant features of machine language coding are:

- It requires an experienced programmer.
- It is usually a one-man operation.
- It requires a considerable length of time.
- It offers great latitude and flexibility in coding.

Many of the difficulties and inconveniences of writing programs directly in machine coding have been eliminated or simplified by the more sophisticated systems of program writing. The computer is used to prepare the programs and eliminate the need for direct machine coding.

A computer can be programmed to recognize instructions expressed or written in problem definition language and to translate those expressions into its internal machine language. This has led to the development of a number of programming languages that are easier to use and understand than the language of the machine.

Symbolic languages permit the programmer to write convenient equivalents of machine instructions using symbols (called MNEMONICS) to represent them. Symbolic instruction representations may include the following: A for add, S for subtract, D for divide, ST for store, B for branch, and so on. The computer, acting under control of previously written machine language programs, translates these symbolic instructions into equivalent machine instructions, which then can be used in solving the actual problem.

Symbolic coding can only be used if and when assembler and/or compiler programs have been developed for a computer. Some of the significant features of symbolic coding and the associated use of an assembler or compiler include the following:

- The number of trained programmers capable of coding more complex problems in machine language is far too small to meet the demands of the rapidly growing applications of computers.
- Writing programs in actual code requires more time than in symbolic code. As problems become more complex, the time difference increases substantially.
- Symbolic languages, because they are written in (familiar) English or mathematical statements, are learned more easily and quickly than machine languages.
- Errors are less frequent in symbolic coding thereby reducing the quantity and hours of expensive computer reruns.
- One of the more tedious tasks of programming, that of housekeeping, becomes much simpler and easier to handle with assemblers and compilers. By assigning meaningful names of indexes, flags, memory locations, starting addresses, and other housekeeping functions, assemblers and compilers can make unique memory assignments and maintain records of such assignments without error.
- The use of significant names instead of numbers makes instructions more meaningful and easier for another programmer or for the user of the program to follow. The program becomes self-explanatory.
- The use of mnemonic names for memory locations, counters and other controls makes it

possible for many programmers to work on subroutines of the same program independently. Names of similar memory locations and controls can be interchanged or equated subsequent to the writing of the subroutines.

• The integration of independently produced subroutines into a program becomes much easier because of the ability to use the same names or to equate names in assemblers and compilers, thereby saving much time and expense in these operations.

ASSEMBLERS

An assembler is a computer program that translates the symbolic instructions of the source program into machine language instructions, makes storage assignments, and assembles the instructions into an object program. The assembler or assembly program, as it is sometimes called, normally results in a one for one translation. That is, it generates one machine language instruction for each symbolic instruction written by the programmer.

COMPILERS

The compiler is a more sophisticated and powerful programming system than an assembler. In addition to its translating function, which is generally the same process as that used in an assembler, it is able to replace certain symbolic instructions with a series of machine instructions. Thus, where an assembler translates item for item, and produces an output the same number of instructions or constants which were put into it, a compiler is basically a one to many translator. The object program which results from compiling is a translated and expanded version of the source program. COBOL and FORTRAN are examples of the many different compilers which have been developed.

INTERPRETERS

An interpretive routine is a computer program which decodes each instruction written in the source language and immediately executes that instruction before translating and executing the next one. Although interpreters have much in common with assemblers and compilers, assembler and compiler programs require two passes through the processor. One pass assembles or compiles the source program into an object program, the second pass executes the program for processing data.

An interpreter routine is often referred to as "load and go." That is, the program is executed with the relevant data in only one pass. This type of program may be good for a one-time job, however, it does not produce an object program that can be reused at a later time, and the source program must be reinterpreted each time it is executed.

REPORT PROGRAM GENERATOR

Generators are general routines which permit a computer to write other programs automatically. An example is the Report Program Generator (RPG) language, which is a technique for producing complete data processing reports by giving only a description of the desired content and format of the output report, required calculations, and certain information concerning the input file.

The programmer writes specifications on simplified worksheets to designate the file definitions and input/output control considerations. These are punched into cards which are used in conjunction with the processor to generate an object program, which is used with the data file to produce a report.

Figures 2-10 and 2-11 show some of the special control forms used by the RPG programmer. The specifications normally consist of the following:

• FILE DESCRIPTION SPECIFICATIONS—Describes the input/output files that will be processed by the object program. Symbolic names are used to identify the files, along with special codes that provide other information about how records are arranged on the file, record length, and so on.

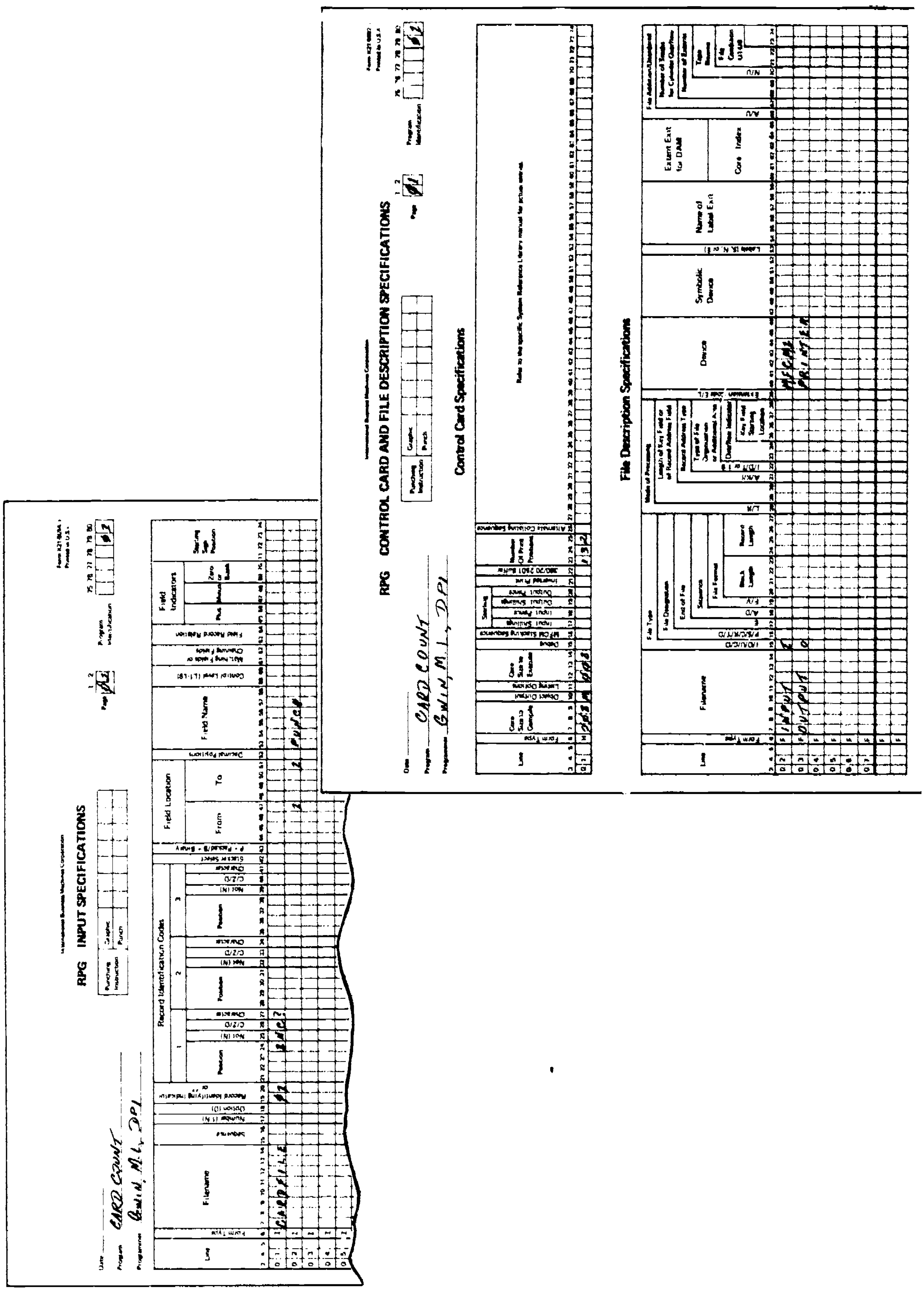
• INPUT SPECIFICATIONS—Describes the data in the files, such as field locations, card columns, control punches, etc.

• CALCULATION SPECIFICATIONS—Describes the calculations necessary to process the input data.

• OUTPUT SPECIFICATIONS—Describes the kind and format of output files to be produced, such as printed reports, punched cards, etc.

HIGHER LEVEL PROGRAMMING LANGUAGES

A disadvantage of symbolic machine language is that it is unique for each make of computer.



78.120

Figure 2-10.—Example RPG program.

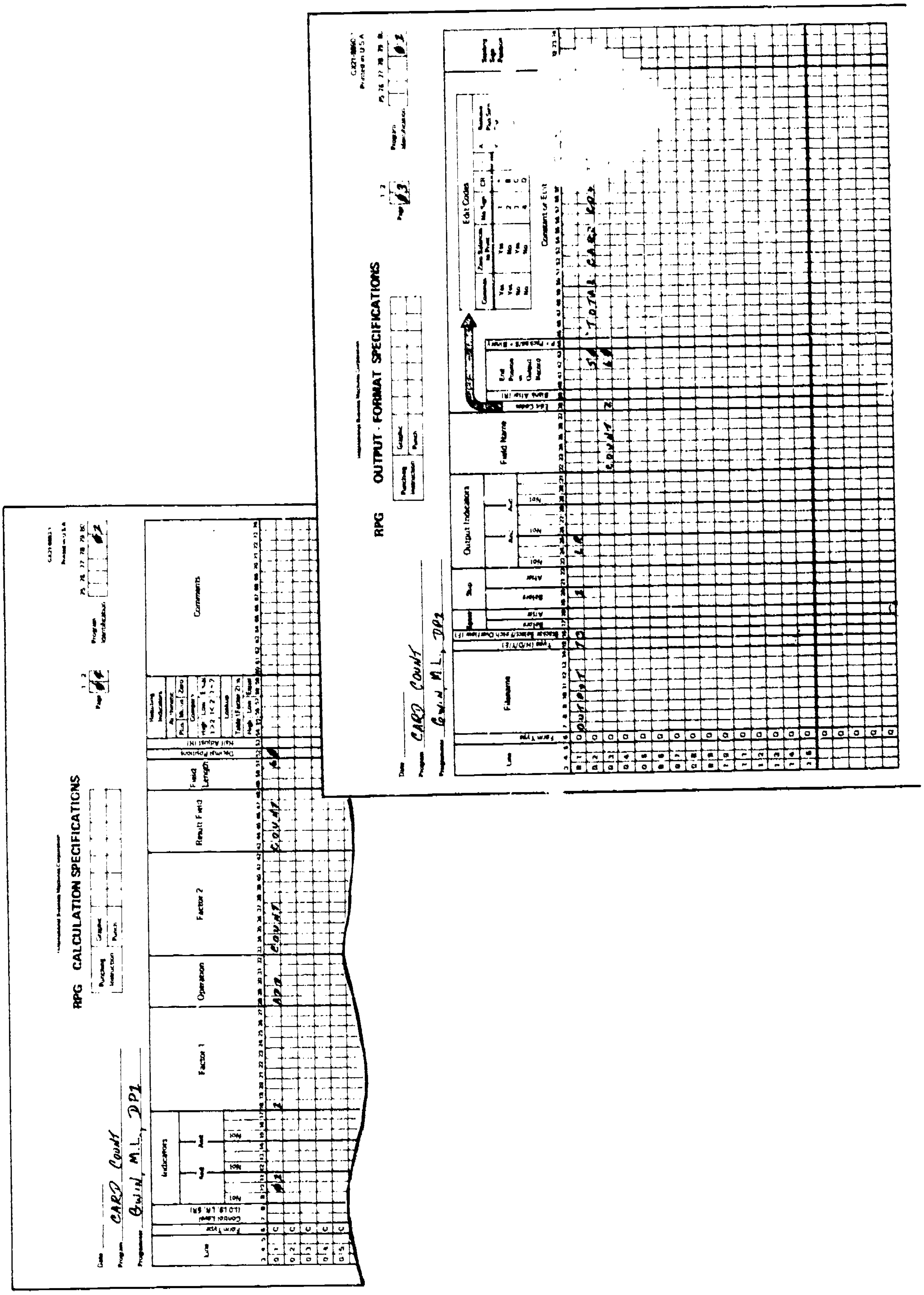


Figure 2-11.—Example RPG program.

Furthermore, a programmer using an assembly language has to pay close attention to details peculiar to his machine. This detracts from his efforts to form the logic connected with the solution of the problem he is programming.

To overcome these disadvantages of assembly languages, higher level languages have been developed. A higher level programming language is one which more closely approaches the language of English and mathematics. It permits the programmer to be less concerned about the individual peculiarities of the specific computer involved and enables him to concentrate more conveniently on the logic involved in the solution of a problem.

The Navy was one of the first organizations to recognize and support the concept of higher level digital computer programming languages. In the past, Navy computers have been programmed primarily in the various manufacturers' assembly languages, and in some cases in the manufacturers' machine code. This has resulted in the requirement for massive reprogramming and/or translation efforts (when changing from computer A to computer B, e.g., 2nd to 3rd generation) or the emulation or simulation of the old computer environment on the new machine. The effect is to incur considerable expense and delay in the former case, and to be deprived of 3rd generation speed and processing enhancements in the latter. In addition, emulation or simulation usually dictates acquisition of the new computer from a specific vendor, thus preventing competitive procurement, which is required by Government policy.

The development and use of higher level languages is widespread. The description of COBOL and FORTRAN which follows is intended to be only a brief survey of the techniques, and it is recommended that interested individuals consult available texts prepared to teach these languages and their usage in detail.

COBOL

Early in 1959, a meeting was called in the Pentagon for the purpose of considering both the desirability and the feasibility of establishing a common language for the programming of electronic computers for business type applications. Representatives from users, government installations, computer manufacturers, and other interested parties were present. The group agreed that the project should be undertaken.

By December 1959, the first version of the language was completed. The name "COBOL," a COmmon Business Oriented Language, was adopted. It was not identified with any manufacturer and therefore presented advantages for both government and private industry users.

With the COBOL system the translator still must produce a machine language program before a problem can be solved. However, the language written by a COBOL programmer bears little resemblance to machine language, and the problem programmer has little direct concern with the method by which the COBOL language program is translated into machine language.

A simple example will best illuminate the basic principles of the problem-oriented type of programming system. Assume we wish to increase the value of an item called INCOME by the value of an item called DIVIDENDS. The COBOL language allows us to specify the addition by writing the following sentence:

ADD DIVIDENDS TO INCOME.

Before the COBOL translator can interpret this sentence, however, it must be given certain information. For example, the programmer will have to write the names DIVIDENDS and INCOME in a special part of the program, called the "data division," where facts about the data represented by those names (such as maximum size, how the data is expressed, etc.) are stated.

When the translator encounters the sentence, it has access to certain information that will aid it in translating the sentence. In addition, it will be able to obtain certain information "built into" the translator itself. (Note, however, that the exact procedure will vary from machine to machine and that, in any case, the problem programmer is not directly concerned with the details.)

First, the translator examines the word ADD. It consults a special list of words that have clearly defined meanings in the COBOL language. This list is a part of the translator. If ADD is one of these words, the translator interprets it to mean that it must insert into the object program the machine instruction (or instructions) necessary to perform an addition.

The translator then examines the word DIVIDENDS. Since it can obtain certain information about DIVIDENDS, it will know where and how this information is to be stored in the computer, and it will insert into the object program the instructions needed to locate and obtain the data.

When the translator encounters the word TO, it again consults the special word list. In this case, it finds that TO directs it to the value of INCOME, which is to be increased as a result of the addition.

The translator must now examine the word INCOME. Again it has access to certain information about this word, and, as a result, it is able to place in the object program the instructions necessary in locating and using INCOME data.

We have indicated that the programmer placed a period (.) after the word INCOME, just as he would in terminating an English language sentence. The effect of the period on the COBOL translator is quite similar. It tells the translator that it has reached the last word to which the verb ADD applies.

The previously described steps are performed by the translator in creating the object program. They might not always be performed in exactly this way or in the same sequence, because machines vary and because each translator is adapted to a particular machine. However, regardless of the machine, the same COBOL language sentence produces machine instructions that cause the object program to add together the values DIVIDENDS and INCOME.

FORTRAN

The FORTRAN (FORmula TRANslation) system is largely computer independent and was designed primarily for programming scientific and engineering applications. The FORTRAN system is very similar in concept to the COBOL system. One of the main differences is in the language the programmer uses to express his source program. Where business English is used by COBOL, mathematical language is used with FORTRAN. The effect of the COBOL sentence

ADD DIVIDENDS TO INCOME.

could be achieved by the FORTRAN statement

INCOME = DIVIDENDS + INCOME

However, FORTRAN translators for some machines might insist that the words be abbreviated to something like:

INCO = DIV + INCO

This would depend on the individual machine FORTRAN translator. The statement, in effect, tells the translator to insert the necessary instructions into the object program to make the INCOME data location equal to the DIVIDEND data added to the present INCOME data. Note that the computer is not merely instructed to find the value of INCOME, but is also told where to put the result of the addition after it is performed. If the original INCOME field (in core storage) contained 10000, and the DIVIDEND field contained 15, the original INCOME field would be replaced by 10015 after the operation had been executed.

If this result is not desired, the programmer could change the statement to:

INCOME1 = DIVIDENDS + INCOME

With this change, a new INCOME1 data field would be generated in core storage, the result of the addition would be placed there, and the original INCOME field would remain unchanged.

OPERATING SYSTEMS (MONITORS)

Another set of language processing and service routines are the control programs commonly called monitors or operating systems. Operating systems arose principally in response to an increase in the cost and speed of computer hardware. In the early days of computing, programmers sat at the main console, and when they wished to stop and think for a while, they pushed a halt button and permitted the machine to sit idle until they were ready to resume. As machine time rose in cost per hour, it was not feasible to allow expensive machine time to go to waste. Thus, programs were written to enable the machine to operate continuously on a sequence of jobs and to administrate I/O operations automatically with a minimum of time-consuming human intervention.

EVOLUTION OF OPERATING SYSTEMS

The first step toward the elimination of idle computer time was the utilization of machine operators to set up and initiate the computer jobs as they were presented by the programmers. They were trained to take standard actions upon the occurrence of any unanticipated machine stops. This helped by eliminating the time consuming practice of each programmer having to run his own program and then trying to trace bugs from the console when something unexpected happened. The machine still sat idle while the operators picked up after one job and set up for the next.

About this time, the idea was conceived of automatically inserting the necessary library routines into a program during assembly so that the programmer would not have to copy library routines and physically include them in his program deck. It was soon realized that if a program could retrieve and assemble routines from a library tape, then a program could be written to read in and stack jobs on a tape. They were then executed in sequence, thus eliminating some of the idle time between jobs. This was the beginning of the concept of Operating Systems. I/O routines were then taken out of the individual programs and included as part of the operating system. The operating system assigned all peripheral devices to jobs. This eliminated idle time while the operator changed reels because one job wanted input from the same tape unit that the previous job used for output.

To further illustrate the evolution of operating systems we might mention the progression from off-line to multi-programming and multi-processing systems. Off-line systems originally were written because of "bottle-necks" developing in the rate of information transfer of such I/O equipment as readers and printers. When a fast computer was hooked up to these devices that could not accept and deliver information at the rate at which the computer could process it, the computer was forced to sit idle while the I/O devices caught up, or was forced to pace itself to the rate of the slower devices. Thus, input began to be prepared and stored on fast intermediate storage media (such as tapes, discs or drums) in a separate and independent process to which the main computer was not connected. Likewise, the main computer would emit its output, at a fast rate, to intermediate media, for later transcription to printed form by slower devices. The slow I/O devices were placed off-line, and I/O was buffered and given its own semi-independent controller in order to get more computation out of the central machine.

Multi-Programming

With the advent of large random-access storage devices, automatic job scheduling was incorporated into operating systems. Now instead of having jobs stacked on tape where they could be retrieved sequentially, they were stored on mass storage. The system was able to pick the job which best suited the criteria of its scheduling processes with respect to availability of resources, job running time, priority, etc.

In multi-programming, when a job causes the computer to halt because some needed peripheral resource is not available at the moment, another job will be read into core storage and be worked on in order that the computer may be kept busy during the delay in waiting for the resource to be made available. Thus, to keep the computer busy as much as possible, the normal sequential order of job processing characterizing the early operating systems was broken, and delays caused by one job are filled by working on others. In multiprogramming systems, many jobs may reach partial stages of completion before a given job emerges complete.

Multi-Processing

The next step in the development of operating systems was the ability to read jobs into the stack on mass storage at random, as space became available. This was logically followed by the handling of multiple job sources, by hooking up extra terminals, both remote and local.

In multi-processing, several central processors, independent of one another, work in a coordinated fashion on a common job mix. With the implementation of random job inputs and a priority scheduling routine, a top priority job could be entered while a long, low priority was running. This led to the concept of priority interrupts, where the low priority job could be dumped to mass storage, to be resumed after the top priority job had been run.

The Navy Tactical Data System (NTDS) made up of a number of computers on different ships all operating together for a given fleet is essentially a single multi-processing system. The software programs which cause these computers to work together with the least amount of wasted (idle) time is in total a multiprocessing operating system.

In recent years, large, ambitious systems with multiple terminals and the availability of priority interrupts, time sharing, where each terminal is given top priority for a short time at periodic intervals have developed as a natural consequence.

CHAPTER 3
SYSTEMS ANALYSIS AND DESIGN

This chapter covers systems analysis—fact finding and critical examination of the facts—and approaches to systems design—deciding what general plan will be followed in design. Together they are the search and initial creative phases: what the present system does, what the proposed system should do, and what schemes can be devised to achieve the desired objectives.

Systems design is the development of a plan or scheme for processing data based on the facts learned in the analysis stage and within the framework developed in the approaches-to-design phase. The systems designer must put together the parts to devise an operating system. This is an entirely different job from that of the analyst, who analyzes—literally takes apart—the process he is investigating in order to understand it.

SYSTEMS ANALYSIS

The fact finding phase, systems analysis, involves collecting, organizing and evaluating facts about a system and the environment in which it operates. This requires determining the demands for outputs—the data and information requirements of an organization for both operating and management purposes—the sources of data, and the processing methods and files that serve as a link between input and output.

OBJECTIVES OF SYSTEMS ANALYSIS

Systems analysis, as used herein, is restricted to factfinding and to examining systems to learn how they work; such analysis is applicable to existing or proposed systems. The objective of systems analysis, then, is to learn enough about a system—equipment, personnel, operating conditions, and demands on it—to establish the foundation for designing and implementing a better system, if it is found desirable or feasible to do so. A data processing system or information system is better only if it increases the net overall output of the organization, after considering the cost of systems design as part of the total costs—including manpower requirements.

Steps in System Analysis

There are nine steps the systems analyst must perform in analyzing a data-information-processing system that is operated by people and uses readable documents.

- Organization—Securing approval for the study, making preliminary contacts with key officials, selecting and indoctrinating the survey staff, and similar preparatory activities to lay the groundwork for the full-scale study are included in this step.
- Planning—Consists of defining and limiting the area of inquiry or problem, setting time and scope of the study, determining procedures or special methods to be employed, considering special aspects, and similar matters. As a general rule, the plan should be developed into a written statement.
- Obtaining facts—By interviewing people and observing activities about the events—their type, volume, and timing—that lead to the origination of documents, maintenance of files, issuance of reports, processing steps done at each work station, and flow of documents between stations. Both physical action and clerical events lead to the creation of more documents or initiation of more action.
- Collecting sample copies—Of filled-in documents, file papers, and reports with facts on activity—smallest, average, and largest number—during each period and the number of lines and characters of data per line to indicate the volume of activity.
- Studying processing operations—To learn the how and why of every document that each person receives or issues, what processing steps he performs, the nature of files he keeps or uses, and the contents of any reports he prepares.
- Organizing the facts—Constructing flow charts, flow lists, or other suitable forms to

trace the path of data from origin, through each stage of communication and processing, into files, and out of files to reports.

• Interviewing the users—To determine what information is required in documents and reports and what is needed in the future. Management and operating personnel demands for outputs influence the systems analysis work in determining how well the present system satisfies the demands. Also, the demands influence selection of an approach to systems design and operating system.

• Documentation—Consists of detailed fact-finding about information flow: data inputs, processing actions, outputs, control points, quantities, file identification, frequencies of transfer, and special time requirements.

• Reporting—The report is a summarization of the entire study. This is the basic record of the study for future reference and is the main tool for obtaining acceptance and installation of the recommended installation and/or change to the existing installation.

PLANNING THE STUDY

The necessity for detailed planning before actually conducting a study cannot be overemphasized. Although survey plans and procedures must be flexible enough to meet special and unexpected situations, it is important that a standard approach be developed and put on paper for these reasons:

• The survey can be conducted more efficiently and with less inconvenience to operating, supervisory, and survey personnel.

• If formal procedures are not established, survey results may be incomplete, inaccurate, or unnecessarily detailed.

• If complete understanding is not obtained among all personnel concerned as to the purpose and scope of the survey and how it should be conducted, the survey work may be unnecessarily slow.

• When standard practices are not followed, it is often more difficult for anyone not originally connected with the survey to understand and use the working papers or the survey report.

• An excellent analysis may not produce results if it is not properly presented.

Getting the Background

One of the first things you should do when setting up plans for a system study is to learn something about the problem. Much useful information can be gathered by:

• Discussing the problem with personnel who are conversant with it and are familiar with its current status.

• Reviewing survey reports, working papers, correspondence, and so forth, which relate to the problem.

• Reviewing existing directives bearing on the problem, such as Navy Regulations, DOD Instructions, and SecNav Instructions.

Preparing the Plan

In planning for a systems study, certain basic determinations must be taken into consideration. These determinations include:

• The approximate starting and completion dates.

• What survey methods, techniques, and special skills are necessary.

• What survey staff is necessary, and whose collaboration, advice, and assistance are desired.

• What facts are necessary for solving the problem and selling recommendations, and which of these facts are available from currently maintained sources.

• The best means for obtaining facts which are not currently available.

• The proper sequence of fact-gathering, so that facts which are needed first can receive immediate attention, and facts which will take the greatest amount of time to acquire can be identified and given priority.

In drafting the written plan, you should regard it not as a final and concrete procedure, but as a starting point, to be revised as experience indicates. It should include:

• A written statement of the mission of the survey—the problem as it is known to exist, and what the survey is expected to accomplish.

• Who is to be assigned to the survey.

• A schedule showing when each major step is to be accomplished and who will perform it.

Organizing for Action

Before getting the actual study underway, it is advisable to first lay the proper groundwork so that the study can be conducted as efficiently and expeditiously as possible. During this time, you may need to:

• Orient yourself in the physical layout, organizational pattern, and procedures of the components to be surveyed. Review organization charts, functional statements, training manuals, personnel list, and so forth.

• Orient all officials concerned with the nature of your mission. Tell them not only WHY but HOW. Time spent in this effort will pay dividends.

• Take pains to establish an open door to the people you want to interview. Start from the top down, so that it is recognized that you have the blessing of top management.

• Arrange for active participation, if at all possible, of a qualified management representative of the organization being surveyed in order to:

1. Promote the attitude that the organization being surveyed still has primary responsibility for solving its own problems.
2. Install and maintain any recommended improvements.
3. Assist in the general orientation of the survey staff, and help obtain necessary working space, facilities, and services.
4. Assist in gathering facts for the survey.
5. Assist the survey staff in promoting good relationships with personnel of the organization.
6. Criticize, comment, and informally advise tentative recommendations or ideas of the survey staff.

CONDUCTING THE STUDY

In conducting a systems analysis, we are concerned ordinarily with two phases:

• The fact gathering or present system description stage.

• The analysis and/or system design stage.

Before we go any further, it must be understood that this text is based on the assumption that this is a preinstallation period and that the job of the analyst does not end with the installation of equipment.

On the basis of this assumption we must determine what the systems analyst's job is and what are his goals. Normally, the analyst's first job is to determine if the area under study can be improved; for instance, by the addition of further mechanization, or—in the case of a manual system—whether it can be improved without mechanization. There should be some productive results in a study of this nature because the system that is perfect and cannot be improved in some manner has not been developed. The goals of every analyst should be the development of "an optimum system within the available resources." This phrase may sound rather meaningless unless we understand that an optimum system is the one which is most responsive to management's requirements.

Management's requirements are the whole reason for data processing. These requirements are the reason we prepare source documents, manipulate the data therefrom and come up with the various records and reports required by management. Therefore, an examination of these reports will reveal if they are optimum. There are many questions that could be asked about these reports but generally the questions concern management needs. For instance:

• Are they timely?

• Are they accurate?

• Is management getting all the information it needs, or is it getting a bare minimum?

• Does management have to wade through a lot of repetitious unnecessary data, mentally extracting those meaningful parts?

Let's consider briefly just what tools are needed to answer these questions.

A system analysis may be approached from either of two angles. One approach is to become completely familiar with the present system and go from there into the design of the new system. Another approach is to determine the end products—the reports to management that will result from the system—and then design a system that will produce these end products.

By employing the second approach the present system may be disregarded entirely. Time and cost savings in connection with performing the analyses are obvious benefits of this approach. Although the first approach requires more time, there are still certain benefits that can be derived from analyzing the current system. First, if we understand the current system, we may ask more intelligent questions of management. Secondly, if we understand the present system, a determination may be made as to the actual cost savings that may be derived from increased mechanization. In some cases, there is not a great amount of latitude in the area of changing regulations and procedures concerning how the data will be processed. This can affect the responsibility of designing a new system. No matter what the approach; the one that best fits your needs is the one that should be used. A combination of both approaches will be utilized here trying to illustrate the desirable features of each, but essentially we will use the idea of working from the management's requirement back through the system. For a reason peculiar to EDPM, it is still desirable, even though working from the end products to analyze and describe the existing system in some detail. This reason is found in the problems of communication between the systems analyst and the programmer who must write the detailed instructions to handle the job. These problems can be alleviated to a great degree if the existing system is described in sufficient detail and in a language common to both.

Authorization to do the job is the first step in doing any study of this nature. This authorization should spell out the scope of the study and provide realistic scheduling of the various phases. Copies of the authorization should be furnished for distribution to each organization concerned.

FACT GATHERING TECHNIQUES

Basically, there are three main methods of gathering information about the present system in a study:

1. Interviewing Personnel
2. Searching Records
3. Sampling

Interviews

The system interview is perhaps the most productive means of securing information. Interviews start with the supervisors of the department being studied as they are the main sources of information during the study. Later, individual clerical and operating personnel may be interviewed concerning their particular job assignments.

In many cases, ideas about future systems may exist partially (or only as thoughts) in the minds of supervisors who can often contribute valuable suggestions concerning the design of the new system. The planner must draw these thoughts out in interviews.

Searching Records

The review of currently used records, documents, organization charts, and historical information provides an important means of fact gathering. All data should be verified with personnel who are acquainted with the subject matter. Observation of actual working activities also provides a source of information that may contribute to a greater understanding of actual procedures and practices.

One point to remember in gathering data from internal sources is that the most important information files to search are usually the ones that are most difficult to secure because of their constant use.

Sampling

Sampling is a measuring technique that is particularly useful on high-volume or complex situations where procedures have not been issued or data is not readily summarized. All sampling investigations are subject to experimental error and should be done with care; that is, no sampling investigation can give absolute results, only a probable value.

ORGANIZATION CHARTS

Before any analysis can be contemplated for a system, it must be known where the data is being processed. The letter of authority has defined the general scope of the study. This scope must be broken down through areas of study to the organizational structure of the organization performing the function to be analyzed. The area of data processing can be easily defined by an up-to-date organization chart. The chart not only defines the organization doing the job, but helps to direct attention to the proper area, thereby eliminating the studying of data processing in a hit or miss fashion. Organization charts can also be helpful as reference charts. For instance, progressing through the study reference to these charts may point out that the scope of the study is out of focus and should be changed. If an organization output is distributed to another organization outside the scope of the study, it might be necessary to include this organization in the study, thereby changing the scope.

Normally, organization charts are obtained from the organization itself. If charts are available from different sources, we should endeavor to determine the most correct source and use only that source whenever possible. When the charts are obtained, they should be checked for completeness and correctness. It may be necessary, in some cases, for the team members to draw their own charts because of lack of sufficient details on the official charts. After the chart has been obtained and verified, it should be initialled and dated. To maintain throughout the study current and accurate charts, the analyst must be informed of any changes to the charts. Organization charts should show the lowest element processing data within the scope of the study.

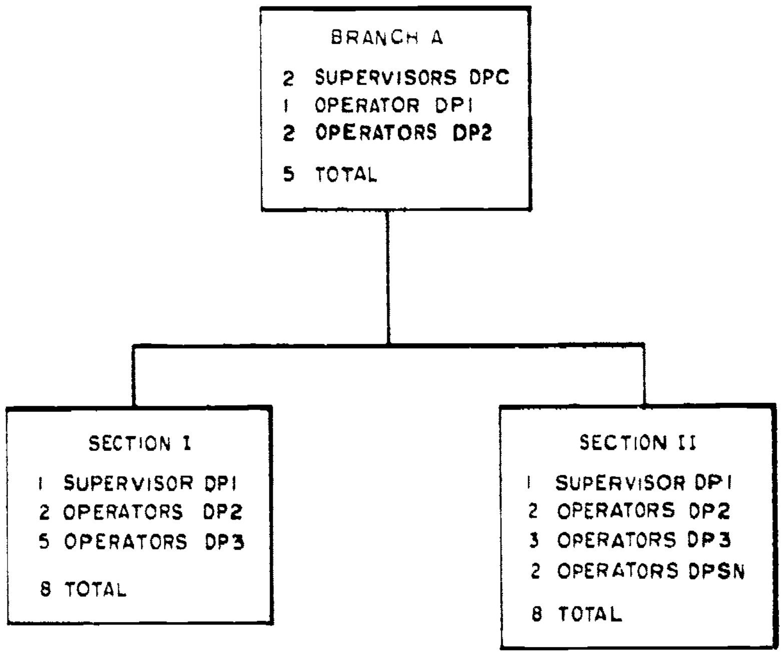
Manning Figures

In addition to knowing where the data are being processed, we must know who is doing the processing. This is accomplished through manning charts. Probably the largest single cost factor in data processing (personnel cost) is determined by the use of manning figures. In addition, they are used in comparing the present system with the redesigned data processing system. Manning figures can normally be acquired from the same source as the organization charts. In some instances, the figures are contained on the organization chart itself.

The method of collecting and verifying organization charts may be applied to manning figures. However, there is one point that must be emphasized, "collect only authorized manning figures." Later we may want to compare the authorized figures with actual ones to determine such factors as cost and understaffing factors. The manning figures should consist of:

- The number of positions;
- The number in the organization;
- The grade level of each member of the organization.

Quite often the organization and manning figures charts give additional information that may be of help in the study. For instance, they might give information as to the mission and functions of the organization. A combination, organization/manning figures chart, is shown in figure 3-1.



78.105X

Figure 3-1.—Combination organization and manning chart.

DOCUMENT COLLECTION

Collecting samples of the documents prepared in the operation under study involves visiting each organization under study and determining which documents they handle. Documents are collected for the following reasons:

1. In order to have a thorough knowledge of the entire system, we must know what documents come into the system, are processed in the system, but do not leave it; and what documents are output from the system. Without knowing every document that passes through, we cannot know the whole system.

2. The new system will have to process many documents that are being processed by the present system. The analyst should be very careful to include all the documents in the system study because in most cases the documents, such as reports, source documents, records, et cetera, will have to be processed whether the processing is accomplished automatically, mechanically, or manually.

METHOD OF COLLECTION

When one views an ADP system as a whole, there may be some confusion as to just where to begin to collect the documents. Let's concentrate initially on the output documents, following the second approach that was discussed.

The output documents consist mainly of reports which leave the ADP system. Therefore, it is necessary to obtain some reports control information such as a list of recurring reports from the shops or headquarters units served by the ADP organization. Armed with this list, we can begin our collection of these documents.

Backup Data

One question will always be asked during the collection of documents. What backs up this document? By asking this question we should be able to trace the report back through the files to the source documents which make it up.

Other Factors to be Considered

We will want to collect several copies of the document as we may wish to file the documents in different categories, i.e., as to its type (output, report, or record), or by organization, etc.

Also, we may wish to obtain completed documents rather than blank ones especially if we are unsure as to the contents of items upon the documents.

We will want to identify the documents according to the organization from which they came. A document may pass from organization to organization as it is being processed. We will collect this document several times, once in each organization. Always be sure to note the organization from which each particular document came, or the organization chart will be meaningless.

Finally, we should pick up all regulatory material concerning the documents such as Regulations, SOP's (Standard Operating Procedures), Memos, and Directives. By understanding these regulations, we may fully describe just what processing occurs on a given document. Regulations also provide information as to why a given document is in the system. The regulatory information is important as we conduct interviews about various documents; it allows us to ask intelligent questions about the documents and processing.

DOCUMENT ANALYSIS

Compiling the vast array of data that may be discovered during the system study requires standards and techniques that will aid in the overall analysis of the problem.

Classification is essential for every document collected during the study. The classification should reflect just how the document will be treated in the ADP system. By classifying documents we define their function within the system. This gives us a clue as to what questions to ask about a given document. We will ask a different kind of question when discussing a report than we would ask when discussing a source document. The questions about the report may emphasize "why," while the questions about the source document may emphasize "where."

DOCUMENT CLASSIFICATION

When documents have been collected they can be classified by type applying the following definitions:

Source Document.—Source documents are the original documents on which are recorded details of transactions—the vehicles upon which data enter the processing system. Because of the nature of the data contained on these documents, the contents must be converted, in a computer system, to machine language on a day-to-day basis.

Intermediate Document.—Intermediate documents are called by any number of names; worksheets, summary cards, et cetera. Normally these documents are internal to a manual or punched card data processing system. Principally, they are used to facilitate the processing of data as opposed to an end product of the system. Normally, a great quantity of source documents (input data) is encountered in a manual or EAM data processing system. All source data must be brought together, edited, and processed to produce the required reports. An intermediate document may be employed to facilitate editing.

Record.—A record is normally thought of as a group of related facts or fields of information treated as a unit, including documents, listings, forms, or any paper that is maintained daily for normal business activities. Reports data are extracted from the record. This document is utilized for reference purposes, for example, a personnel diary.

Report.—The report, as used by management for decision-making and/or planning, includes any document, or other paper that can be used for this purpose. The report is the end result (product) of data processing, and as such, should not require further processing. The report should not "backup" any other document.

Developing a Classification Code

We may find it convenient to develop a classification code to assist in distinguishing the four types of documents. These codes may be represented numerically (1 = source document, 2 = record, 3 = intermediate, and 4 = report), alphabetically (A = source document, B = record, C = intermediate, and D = report), or by any other method of coding, as long as it is a standard code for every member of the team and is applied throughout the study. For our purposes, we will use the alphabetic code. In 90 percent of the cases encountered, each document will have one and only one code. In the other 10 percent, the document could have two codes. When the function of a given document changes, it is reflected in the code change. A document could possibly serve as a source document and later re-enter the system as an intermediate document. However, this is a rare case and should not occur frequently.

Referring to figure 3-2, we can see that more than one department requisitions pencils as needed. Utilizing the code A we may classify these requisitions as SOURCE DOCUMENTS. The supply departments update their stock RECORDS (code B) if the pencils are issued. An inventory is performed at the end of each month showing the quantity and distribution of pencils. This constitutes the INTERMEDIATE DOCUMENT (code C). This inventory is the basis for the pencil REPORT (code D).

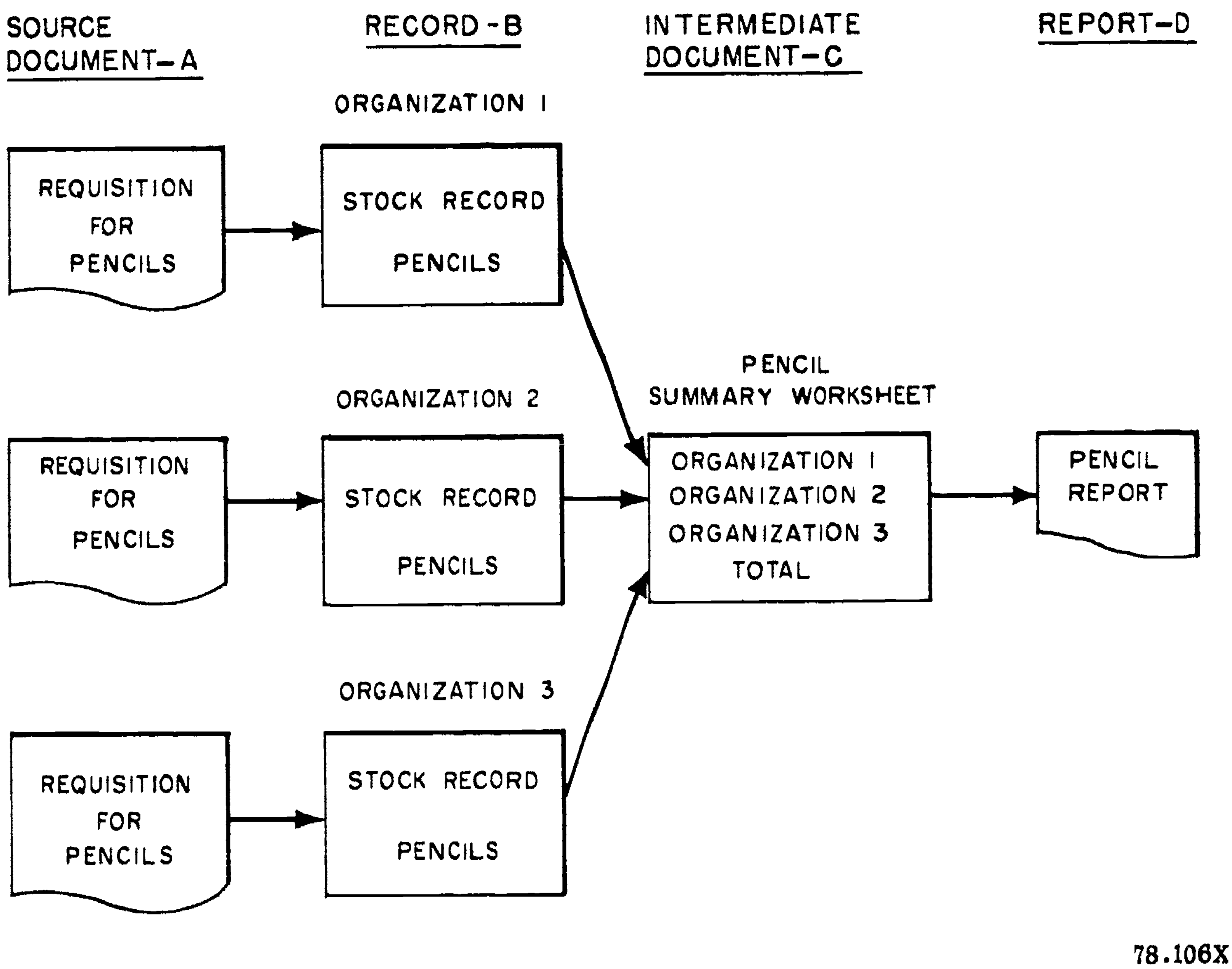


Figure 3-2.—The pencil report processing.

Now we have the picture of data processing from the origination of data as source documents to the reports demanded by management. The illustrations may seem a little unrealistic, yet the relationship of classification to data processing is obvious.

Code Application

The developed classification code may be applied as documents are collected. Documents may be classified as SOURCE DOCUMENTS when there are NO documents backing them up. REPORTS are those documents that are backed up, but do not back up any other document. RECORDS are those documents which are processed on a daily, as required, basis, but do not fall into either of the two aforementioned classifications. The frequency of the documents must be taken into consideration here. Those documents that are processed on the basis of weekly, monthly, or longer time periods may appear to fall into the record category but may actually be INTERMEDIATE RECORDS. The general statements above may not apply to all coding situations. Each document must be considered according to its function to determine its classification.

END REQUIREMENT ANALYSIS

To complete a successful study we must understand the end (output) requirement, which means that we must gather sufficient data to define each report requirement. One method used to accomplish this is to summarize each end product on a card (fig. 3-3). This could be a 5 x 7 or larger card. The size should be standard for all members of the team. Care should be taken in the gathering of data to cross-check information with several people to assure accuracy and completeness. It may be possible to mimeograph a number of cards to include as a minimum the following categories of data:

- Identification
- Distribution and use

IDENTIFICATION: PENCIL REPORT

DISTRIBUTION AND USE: TO SUPPLY OFFICER AND FILE

FREQUENCY: MONTHLY ALL DATA DUE IN 25th DAY

ELEMENTS OF DATA:

	SOURCE	AVG	MAX	% OF USE
DEPARTMENT NUMBER	PENCIL SUMMARY	6	6	70
BOXES OF PENCILS ON HAND	PENCIL SUMMARY	4	7	90
NORMAL QUOTA	STOCK RECORD	2	7	100

END PRODUCT CLASSIFICATION: STATUS AND MANAGEMENT CONTROL

VOLUME: 6 COPIES (SUPPLY OFFICER AND 5 DIVISIONS)
AVERAGE, 125 LINES; MAXIMUM 150 LINES

FORMAT: SINGLE LINE

SPECIAL CONSIDERATIONS: IN LATER ANALYSIS, EVALUATE CAREFULLY AS TO ANY PRACTICAL VALUE FOR THIS REPORT

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Figure 3-3.—Areas of end product analysis.

- Frequency
- Sequence
- Elements of data and their sources
- End product classification
- Volume
- Format
- Special consideration

Identification

A few words of identification should be placed at the top of the card for each end product. Typical items of identification data are report title and number.

Distribution and Use

Understanding distribution and use usually requires interviewing each person receiving a copy of the report to determine:

- His job title, function, and responsibility.
- Why he receives the report.
- What information he requires from the report.
- The basis for the action (if any) he initiates as a result of this report.
- What information he might add to the report.
- Disposition of his copy of the report.

If a report is relayed, you must follow it until it is filed or destroyed, gathering the same information as for any other report. During the interviews, request criticisms of timeliness, suggestions for improvements, information content, and format of these items. All cards for each individual should be collected before he is interviewed. Obviously each interview should be conducted in a manner that will gain the cooperation of the persons interviewed and will enable you to obtain the needed information with a minimum of interference with regular work schedules.

Frequency

When the frequency of reports is studied, the following related questions should also be answered:

- Are the reports run according to a particular cutoff date, such as monthly closing, inventory date, etc.?
- If reports are run by cutoff dates, when are the data due for the report?
- Is there a schedule for the report or is it run on demand?
- If the report is run on demand, who is the requesting authority and what is the basis for requesting the report?

Sequence

In generating a new report, it is necessary to make a careful analysis of the control criteria (fields of data used to establish the sequence of the report). For example, personnel reports may be listed by name, rank, or serial number. If the criteria are rank and serial number, there must be a reason inherent in the purpose of the report that accounts for this sequence. Before the report can be generated we must know:

- What the controlling criteria are.
- When the criteria change. What summaries and/or calculations are shown, for example, a change from one department to the next.
- Why the report must be run in a particular sequence.

Elements of Data and Their Source

The basis for all analysis is a detailed understanding of the data elements to be produced by the system. For instance, the identity and source of each element of data shown or the report during the reporting process. What elements of data are generated and how, and for each item the maximum and average size and percentage of occurrences.

Classification of End Product

Without classifying, it is next to impossible to understand and analyze end products. End products may be classified according to: status (or activity), or management control versus systems documents. According to status or activity, a report usually reflects a balance or status as of a given cutoff date (a balance sheet) or a summary of activity over a given period (a profit or loss statement). Sources for generating the report may be determined by this method of classification. On the other hand, according to management control versus systems documents, a report is usually used by management to measure, evaluate, and/or analyze an operation, or it may be a systems document used by the operating personnel as a vital link in the chain of operations (production schedule, etc.). Since the approach to the management control report is quite different from the approach to the systems document, the analysis of a report is aided by this classification.

Volume

The volume of data associated with a report will determine the efforts required to produce it. An understanding of this volume is invaluable in grasping the magnitude of the job. Principally there are two factors involved in defining volume: the maximum and average number of lines per form, and the maximum and average number of forms or sheets.

Format

The complexity of the editing procedure required to produce a report, may be defined through a careful study of the required format. The format study will determine:

- How many copies are required.
- If it is a single line item or a more complex multi-line format.

Special Consideration

To aid subsequent analysis, other questions should be answered, such as: does any report receive any special consideration? Are there any special remarks that could be noted for use in subsequent analysis?

ANALYSIS OF MAINTAINED FILES

Perhaps you are asking yourself why bother analyzing files; shouldn't we be primarily concerned with operating procedures, reports, equipment, et cetera? You will see in the following paragraphs that a complete analysis of maintained files is a very important part of system analysis. The following information should be included in a written survey of the files:

- This identification and statement of the purpose of the file.
- A numerical statement of maximum size, average size, and percentage of occurrence of the elements of data contained in the file.
- The volume of data for average periods, and the possibilities of future file expansion or reduction.
- The sequence of data in the files, and the reasons for that sequence.
- The file maintenance schedule.

It is advisable to detail all this information on a data sheet similar to the one illustrated in figure 3-4, and summarized on 5 x 7 cards for each file maintained. The areas of file information are contained in more detail in the following paragraphs.

Identity and Purpose.—The file should be identified in a concise and clear manner. This information, along with the reason or reasons for the maintenance of the file, should be placed at the top of the card prepared on this file.

Elements of Data.—A listing of the data appearing in the file should be placed on the card along with the average and maximum size of the elements of data and their percentages of occurrence.

Volume.—The volume of data affecting the file during average and peak periods should be shown on the summary card. Any possibilities for file data expansion should be noted.

Sequence.—Major intermediate, and minor sequences used in the file should be noted on the card.

Frequency of Maintenance (Updating).—A statement on the card concerning the updating frequency of the file is important. Is the file updated daily, weekly, bi-weekly, monthly, etc.?

Special Characteristics.—Any special characteristics of the file should be noted and explained.

SOURCE DOCUMENT ANALYSIS

Another essential phase of a system study is the analysis of all input items. The 5 x 7 card can be used again for each input item so that it can be easily handled. The following information should be contained on each card:

- A definition of source document and a statement of its purpose.
- Methods of organization.

DATA SHEET

IDENTIFICATION	NO. OF MSGS
MONTHLY PERSONNEL STATISTICS	6,000
SEQUENCE	USE
COST CENTER-EMPLOYEE NUMBER	PERSONNEL

REMARKS
INTERMEDIATE FILE

ITEM NO.	SUB ITEM	DESCRIPTION	CHARS. MAX	CHARS. AVG.	% USE	WTD. AVG.
1	a	DEPARTMENT	3	3	100	3.00
	b	EMPLOYEE NUMBER	5	5	100	5.00
	c	INSURANCE STATUS	1	1	100	1.00
	d	SHIFT	1	1	100	1.00
	e	GRADE AND STEP	2	2	100	2.00
	f	AGE	6	6	100	6.00
	g	INSURANCE DEDUCTION	3	3	100	3.00
	h	GRADE AND STEP DATE	5	5	100	5.00
	i	OLD DEPARTMENT	3	3	100	3.00
2		SKILL CODE	4	2	100	2.00
3		EMPLOYEE NAME	24	15	100	15.00
4		RETENTION PREFERENCE	3	2	100	2.00
5		EDUCATIONAL STATUS	3	2	100	2.00
6		BASE RATE	5	3	100	3.00
		TOTAL CHARACTERS OF INFORMATION	68			53.00
		ADDED CONTROL CHARACTERS	8			8.00
		TOTAL RCA CHARACTERS	76			61.00

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Figure 3-4.—Data sheet for maintained files.

- Elements of data contained.
- Peak and average volume and periods when peaks occur.
- Frequency of preparation.
- Files affected.

Identity and Purpose.—The identifying words should be brief but fully descriptive. This should appear at the top of the card along with a short explanation of the purpose of the source document.

Method of Origination.—The point and method of origin are important items. This information when assembled will point out the presence of the duplication of input items in any division of the operation, and will lead to a combination of documents that are similar in nature.

Elements of Data.—The elements of data appearing on each input document should be listed on the card prepared for that document, indicating its fixed or variable nature. Further statements should also be given regarding average and maximum size of the data items and their percentage of occurrence.

Volume.—The volume of data contained on the source documents will vary in accordance with daily, seasonal, cyclic, and long term activities. These variances in the volume of data should be noted on the summary card.

Frequency.—The frequency of preparation of source document should be noted on the card. The notation might read: prepared weekly, prepared daily, or whatever is appropriate.

Files Affected.—A listing of the files affected by a particular source document should be listed on the card prepared for the source document.

TOOLS OF SYSTEMS ANALYSIS

It has been said that the first and most important tool of systems analysis is simply an analytical frame of mind. A thoughtful questioning attitude is most important when attempting to study an information system. The other major tools of systems analysis are the interview, grid charts, flowcharting, diagramming, and visual presentations.

Charting should be used to make facts more understandable. All data to be recorded will not be limited to chart form. Other techniques that are used include narrative information, statistical tables and data, samples of operating documents and forms, and results of sampling, tests, and observations. We have already discussed some of these methods, such as organization charts, document collection and cataloging. Some other important methods are discussed in the following paragraphs.

INTERVIEWING TECHNIQUES

As a fact gathering technique, the interview has a number of special advantages in that it provides a way of securing information not recorded elsewhere except in the mind of the person interviewed. Ideas, the significance of which neither party had previously realized may be developed in the give and take of a discussion.

The interview can be used as a promotional tool. Explaining the why and how of your technique will develop understanding which will pay off later. The face-to-face contacts during the course of the survey can be used to build an attitude pattern toward you, and can improve the information you obtain and the reception your recommendations later receive. A few points to remember when planning an interview are:

- Prepare beforehand (and follow) an outline of topics that will be covered. Don't become involved in day-to-day problems unless they have impact on the study.
- Don't prolong interviews by attempting a detailed analysis of the information during the interview.
- Avoid giving the appearance that the interview is really a thinly disguised time study.
- Learn to separate fact from opinion as soon as possible. Opinions, of course, may be extremely revealing and should not be ignored, but they should be labeled as such.
- Interview personnel representing both sides of significant topics. For instance, interview both the senders and receivers of important internal documents.
- Question all levels of personnel about the improvements they would recommend if they were in a higher position. Be sure to credit them when discussing these recommendations with others. Keep all interviews informal, yet businesslike.
- Request each manager to introduce you to people within his organization whom you will interview in the future.
- Arrange appointments as far in advance as possible.

Special Problems of Interviewing

There are special problems connected with interviewing, both in your own attitude and in the attitude of the person interviewed.

Concerning your own attitude, it is easy to fail to take into account your own preconceptions as to the results you would like to obtain. That is, instead of objectively attempting to get the facts on a particular situation, the natural impulse is to arrive at a tentative conclusion and then attempt to get the necessary facts to back up this theory already half-formed. Nothing could be more detrimental to a successful systems interview. Likewise, when a new situation arises, there may be an unconscious attempt to associate it with some past experience. Even highly experienced analysts, who may have used certain methods successfully in the past, have a tendency to attempt to straightjacket the existing situation into this previous experience. Another pitfall is that personal experience may have left you with prejudices for or against certain types of people or personalities.

During an interview, you should be on the lookout for attitudes of the person you are interviewing, such as:

- Nervousness.—Even those persons who are in sympathy with the general aims of your program are apt to be a trifle nervous under the actual strain of an interview. This barrier to free and easy exchange of information can be overcome however, provided you take the initiative and maintain control of the interview.
- Over-response.—Through a desire to appear cooperative, the person interviewed may supply answers which he deems to be most favorable to you rather than state the facts as they exist. Questions should be carefully worded to avoid suggesting an answer.
- Conjecture and inaccuracy.—The person interviewed may give information without thoroughly checking his facts or considering what he is saying. This is true especially if he feels he should know all the answers, since he may be prone to guessing rather than admitting he does not know. Questions should be precisely worded to require specific factual answers, if facts are desired. In some instances an interviewee's opinion may be of value, but in your questions and in noting his answers, be sure to distinguish between opinion and facts.
- Cautiousness.—Directly opposite from the ambiguous person is the cautious one who answers questions only when he is positive the answer is correct. He may withhold valuable information if he is not absolutely sure of its accuracy in every detail.
- Resentment.—A person with a hostile or resentful attitude toward what you are trying to do is perhaps the hardest to get any concrete information from. He may have any of a number of reasons for not wanting to cooperate, such as being adverse to change, fearful of losing his job to machines, or just too busy to be bothered. A considerable amount of tact and resourcefulness must be called into play to convince him of the need for cooperating in the systems study. Often such resentment stems from lack of understanding of the exact purposes of the study, engendering fears that the quality of his work may be in question or that new equipment or procedures may endanger his position. Many such fears can be allayed by careful explanation of the purposes at the start of the analysis.

Preparing for the Interview

Adequate preparation should be made before the interview takes place. Many interviews fail because they are not sufficiently planned or prepared for. General guidelines in preparing for an interview are:

- Decide specifically what is to be accomplished by the interview, what information you want from the person you are going to talk to, and the general approach to be taken.
- Become sufficiently familiar with the subject matter by studying the functional organization charts, procedural manuals, or other materials which describe the functions of the work area to be analyzed, so that you will have an understanding of the terminology and technical explanations likely to be given.
- A well planned interview sets a conversational pattern that leads naturally from one related subject to the next in an easy flow of words and ideas. Outline a few key questions that can be used to open new areas of discussion as the interview proceeds. Give particular attention to the initial statements, since the first few minutes of the interview may determine the reception given to you during the remainder of the time.
- The most productive method of approach, both in leading up to and during the interview, is the frank and forthright one. In your contacts with the person to be interviewed, the following are essential:

1. Explain the objectives of the survey and the objectives of the desired interview. Give a brief description of the subject matter to be discussed and the general type of information that will be needed.
2. Emphasize the importance of the part the person to be interviewed will play in assuring the success of the survey.

3. Make an appointment. An analyst must acknowledge the natural human dignity and importance of every person in the organization to be surveyed, from messenger to Commanding Officer. One way to acknowledge this is not to assume that anyone can lightly drop any task on which he is working in order to be interviewed. If at all possible, you should make a definite appointment in advance with any person you desire to interview. Failure to take into account this small but important detail sets up a needless obstacle in the path of successful interviewing.

Tone of the Interview

Conduct the interview as informally as possible consistent with the need for an organized and planned result.

Be courteous but in no way apologetic. It is assumed that the interview is necessary and important, otherwise it would not be taking place. To make disparaging statements serves only to raise questions in the mind of the other party and in no way adds to the interview.

The tone of the interview is a reflection of the mental and physical attitudes of the interested parties. If they are relaxed, friendly, and informal, the interview will proceed smoothly. It is mostly up to you to bring about this desirable situation. You must endeavor to render all possible assistance but in so doing be genuine and sincere. Interest cannot be successfully pretended, but must really exist, since people are quick to recognize it and usually react in a favorable manner. Attempt to be truly relaxed, both physically and mentally, and do all within your power to have the person interviewed follow suit.

Remember to be complimentary whenever you can, but never give adverse criticism—you are only seeking facts at this point.

Guiding the Interview

The interview should be limited to information gathering. While free discussion should be encouraged, be careful not to be drawn into too many conversational detours. Gently pull the interview back to its intended purpose at the earliest opportunity if there is too much digression. If such an opportunity does not actually occur, it is your problem to make one yourself. You must retain the initiative in guiding the interview and holding it within well-defined channels.

You are not a crusader and should not try to sell anything or argue with statements which you believe to be wrong.

Do not commit yourself to any specific recommendations or course of action even though you may have formed tentative ideas. There may be a tendency on the part of the person being interviewed to try to find out your thoughts on particular situations, but you should not be drawn into any statements of opinion. It is not what you believe a situation to be that is important, but what the situation actually is. Be very reserved with respect to statements or comments dealing with any tentative conclusions you may have formed while on the job.

Ending the Interview

Prolonged interviews rarely are desirable. If it is necessary to discuss a work situation for more than an hour at one sitting, you might split the discussion into two sessions, or at least take a break for coffee. Interviews are hard work for all parties concerned; in addition, people who are being interviewed usually are under a certain degree of tension. Unless due allowance is made for this factor, fatigue and the desire to "get it over with" may prompt the person interviewed to make incomplete or incorrect statements. On the other hand, as the interview progresses, if it becomes evident that all of the ground cannot be covered in the allotted time, make another appointment that will be mutually convenient. No question that is important enough to have been included in the interview plan should be eliminated simply because the time runs short on a particular day. While expedition is desirable, it should not be placed over completeness.

Always end an interview in such a manner as to permit informal checkbacks, if required, by introducing some comment that will leave the door open for subsequent interviews. Also, explain briefly that when flow charts are completed on the procedure discussed in the interview, they will be brought back for purposes of verifying the facts of the procedure. This brings the person interviewed into the process of analysis, contributing to a feeling on his part that this is his survey as well as yours. It provides an opportunity to explain the tools and techniques used in your study.

When ending an interview, it is good practice to indicate the fact by some physical act, such as pushing back a chair, standing, et cetera. You should be alert at this time for significant statements of information. When the person interviewed believes the interview has ended, he may unconsciously relax any mental guards he has set up, with the result that he may provide items of information that have previously been withheld.

GRID CHART

A systems analysis tool which can be used to describe a wide variety of relationships, and thus is valuable in many types of analysis, is the grid chart. It may be used with complete documents or elements of data and has been found to be of particular value when coupled with document classification. It is helpful in pointing out areas of unneeded data, redundancies, areas where documents can be combined, providing clues as to the extent of integration which is possible in the system under study, ensuring completeness in collection of documents and correctness of coding. Figure 3-5 depicts an everyday example of a grid chart. Suppose you were in Washington, D. C. and wished to go to Atlanta, Georgia. Upon an examination of the plane schedule you will soon see that flights 402 and 505 stop in Atlanta; therefore, these two flights would be the ones containing the data you are looking for. This is a very simple illustration of the grid chart and its use.

Now let us examine a grid chart that might be used in a data processing application.

Construction

A typical data processing grid chart is divided into three sections: heading, input, and output, a discussion of which follows.

Heading Section.—The heading section is divided into three areas (fig. 3-6):

- Major area—the area under study (supply, personnel accounting, etc.).
- Subarea—(inventory, receipt, etc.).
- Organization—the organization that is doing the data processing.

This chart may be expanded, if desired, to an area chart or even to one that depicts the whole scope of the study.

Input Section.—Every input document that backs up a given document should be reflected in the input section. The document's title, form number (if any), and classification should be recorded in the input section. This section may reflect source documents, records, and intermediate documents.

Output Section.—Every output document of the system should be reflected in the output section. The document's title, form number (if any), classification, and frequency should be recorded in the output section. This section may reflect reports intermediate documents, and records. By placing an X in the proper square the relationship of the input and output can be seen.

	FLIGHT NUMBER		
	402	505	706
LV WASHINGTON	5:00 PM	7:05 AM	11:00 AM
AR ATLANTA	6:45 PM	8:50 AM	- - - -
AR JACKSONVILLE	7:30 PM	- - - -	- - - -
AR MIAMI	8:30 PM	10:20 AM	2:55 PM

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Figure 3-5.—Typical working grid chart.

MAJOR AREA: SUPPLY					
SUB AREA:					
ORGANIZATION: ADMIN. DIV. RECORDS SECTION					
	FREQUENCY ►	D	M	M	
	DATA CODE ►	B	C	D	
	END PRODUCT / INPUT DOCUMENTS	STOCK RECORD	SUMMARY	PENCIL RPT	
A	REQUISITION	X			
B	STOCK RECORD		X		
C	SUMMARY			X	

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Figure 3-6.—Document grid chart.

Analysis of Grid Chart

Now let us study this grid chart in the light of what we already know about the various types of documents.

1. Reports by definition should not back up further processing. Hence, they should only appear as output, and in the output section. Data code "D."

2. Source Documents by definition are not backed up by any other document. Hence, they should only appear as input, and in the input section. Data code "A."

3. Records by definition may or may not back up other records, intermediate documents, or reports. Hence, they may appear in either or both of the input and output sections and either as input, output, or both. Data code "B."

4. Intermediate Documents are used in the preparation of reports and/or records. Hence, they serve as input to these documents. Intermediate documents are derived from source documents, and/or records, and serve as output from these documents. Intermediate documents must appear in both the input and output sections, with one exception. An intermediate document may not appear both as input and output within a single organization. One organization may develop a given document shown as output, yet the same document may be used by another organization as input for a report preparation. Utilizing this rule as a basis, we can see that a comparison of all organization charts, in a given area should be performed to ensure that all intermediate documents do serve in both sections.

5. We should be able to trace every report back to one or more source documents.

When verifying a completed document grid chart, the following are things to look for:

- Incompleteness—by violation of rule 5.
- Miscoding—by violation of rules 1, 2, and 4.
- Documents outside the scope of the study—by violation of rule 5.

If any violations of these rules exist they may be resolved by reinterview. In reviewing figure 3-6, we can verify its correctness by applying all five rules that were previously discussed. To check the accuracy of rule 5, refer to the report data code D, in the output section. Looking down the chart we come to an "X" and following the line we see that the report is backed up by the summary, data code C, in the input section. By tracing the summary, data code C, in the output section and repeating the same sequence for reports, we see that the summary is backed up by the stock record, data code B, in the input section. Finally, we can see that the stock record, data code B, in the output is backed up by the requisition, data code A, in the input section. All processing may be traced from report to source document on any grid chart by this method.

FLOWCHARTING (CURRENT OPERATIONS)

Flowcharting is a part of every system study. It is a means of visually representing information, flow of data, and the sequence of operations in a data processing system.

The basic concept of flowcharting is to use standard symbols throughout, to ensure that a particular symbol means the same to everyone. The system should be charted as it presently exists and then, if changes are recommended, another chart should be prepared showing the system as it would be with the proposed changes. There are many reasons why the present system should be charted. Below are a few of the most important.

- Charting is helpful in the analysis and discussion of the system when some members of the team are not familiar with the area under study and/or if the study is a complex study, covering many areas.
- The technique is useful in locating steps that can be eliminated because they are redundant.
- When cost accounting is necessary, charting aids in accuracy of costing. When improvements are proposed, the new system should also be charted, so that a comparison of the two charts will assist in comparison of costs.
- The charting technique is especially helpful in picturing operations for the various manufacturers, thereby resulting in more responsive proposals.

Basically, flowcharting can be categorized into two types:

- System flowchart
- Flow process chart

System Flowcharting

System flowcharts depict the flow of data through all parts of a DP system and include the operations performed in the system and the sequence in which they are performed. Often such a chart is composed solely of symbols that represent only the form in which data appear at various stages of processing. In all instances the system flowchart can be extended, by the system analyst, to an operational flowchart to show the job steps involved in the development of information as well as the documents themselves.

Overall, system flowcharts show what is to be accomplished. They represent an application in which data provided by source media are converted to final output media. Here, the main emphasis is on the documents involved, and secondary emphasis is on the work station through which they pass.

Flowcharting and the symbols shown and described in figure 3-7 are discussed in the Data Processing Technician 3 & 2 manual.

Flow Process Chart

Once the system flowchart has been completed, the foundation is laid for developing the second type of chart, the flow process chart.

In preparing the flow process chart, it is essential to interview (see interviewing techniques) those people who are engaged in the actual data processing. This is necessary to determine the steps and sequence of processing. This method of charting is concerned with tracing data elements from the source document on which they enter the processing cycle to their appearance on the output report. Usually the chart is constructed within the organizational structure, thereby showing what elements of data are utilized in processing as a given document passes from organization to organization.

A form may be employed by the flow process chart in gathering recordings of the operations. Because of convenience in use, this form makes possible a rapid shorthand method of recording the present system. Basically, this form consists of three sections (fig. 3-8) which are:

- Heading
- Flow process chart
- Narrative

Heading Section.—The heading section (fig. 3-8) contains entries which are mainly identification information. The contents should include, but not be limited to:

- The description of the document including title and form number
- The organization where the document is being charted
- The date
- The interviewee (for possible reinterview)
- The interviewer
- The interviewee title (for costing)
- Distribution (including all copies as well as files

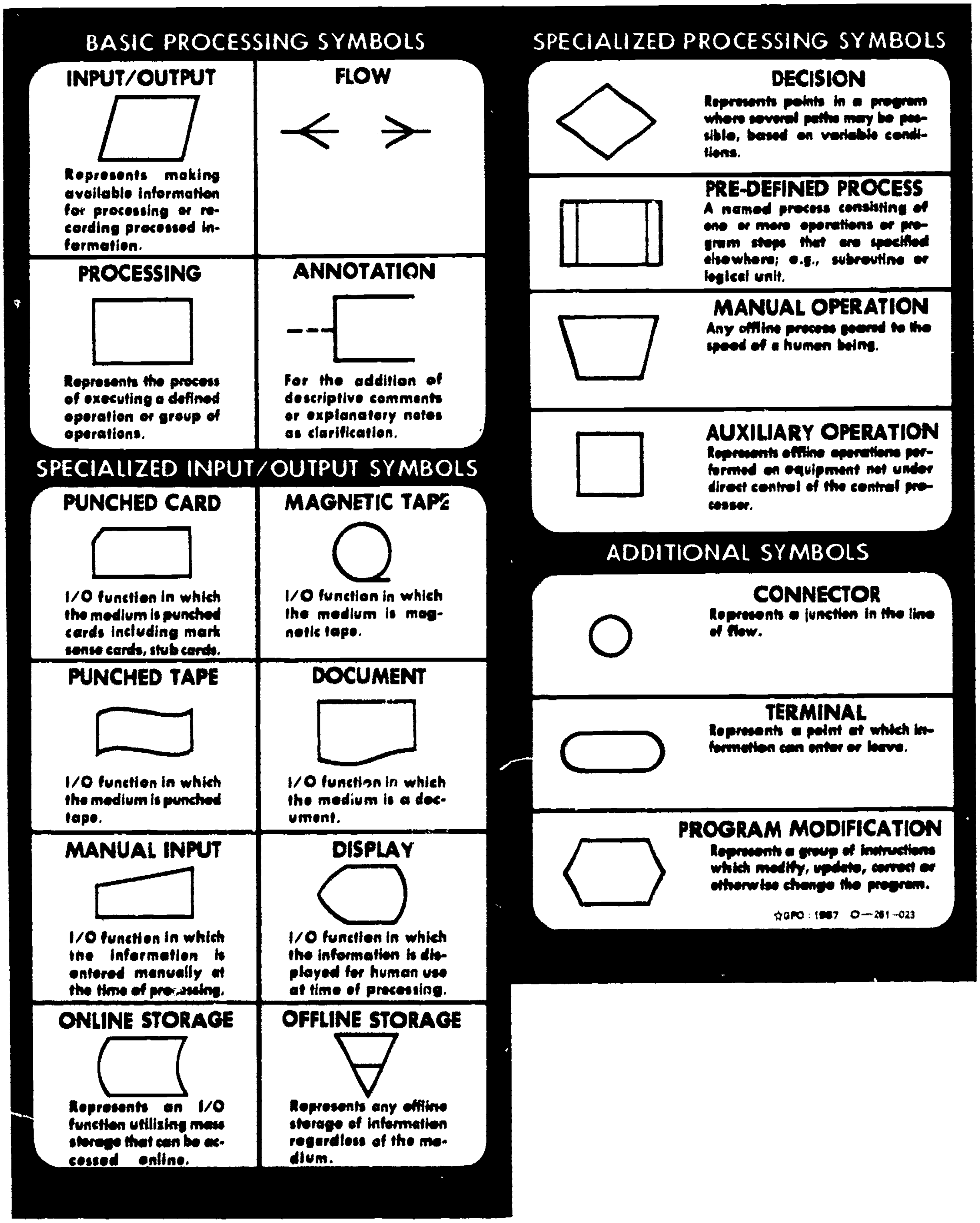

Figure 3-7.—Flowchart symbols and their descriptions. 78.122

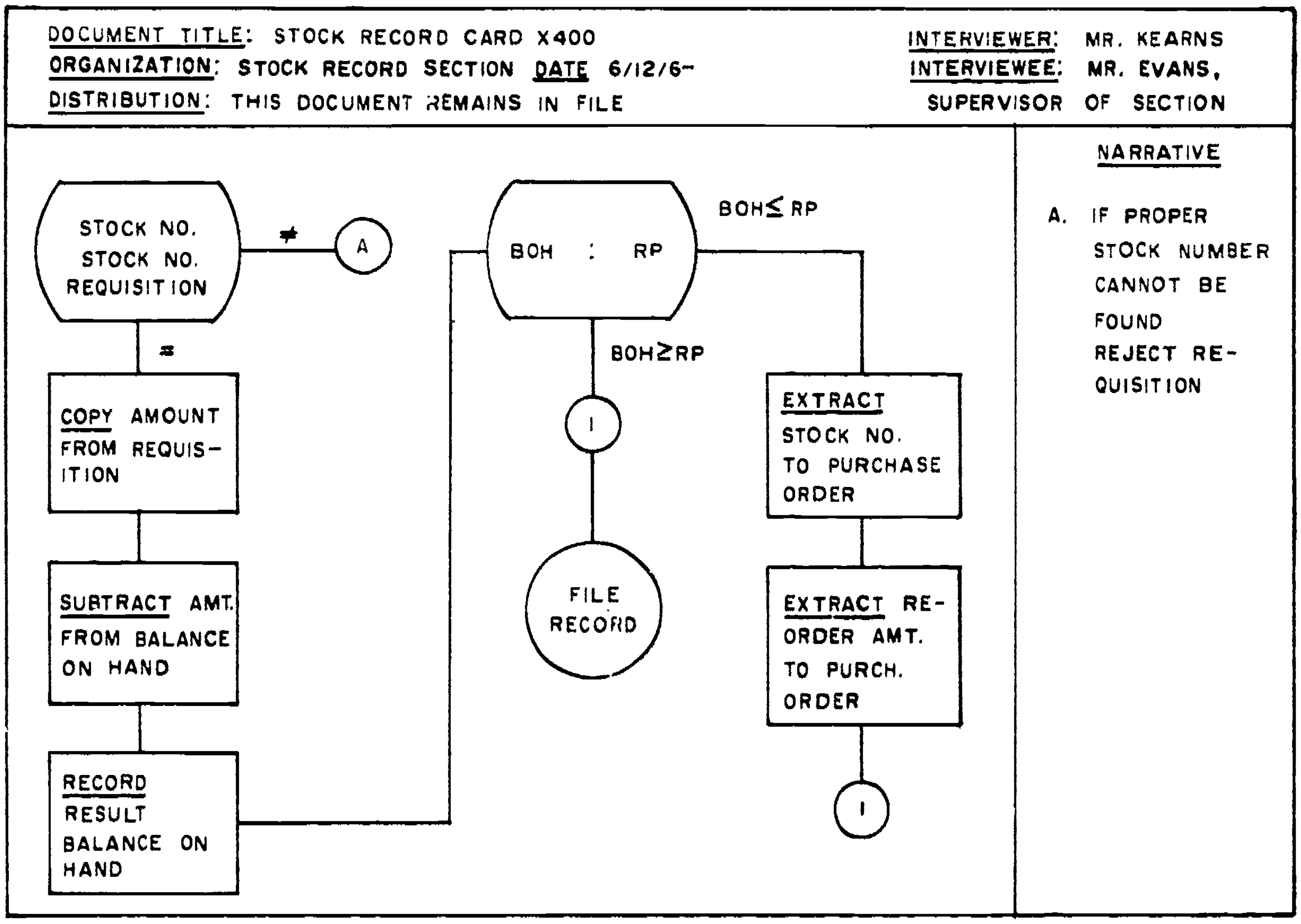

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Figure 3-8.—Flow process chart.

Flow Process Chart Section.—The method of charting is not fixed, but everyone on the team must utilize the same conventions. Once the charting mode has been established it must be followed by all team members so that all charts can be read and analyzed easily. The flow process chart may be drawn horizontally or vertically and contains symbols, verbs, and elements of data description. The following symbols should not be construed as the only method of representing operation. However, these symbols are used by a major manufacturer of data processing equipment and are used in their educational program. It is recommended that the number of symbols used be kept to a minimum. These symbols are identified by number in figure 3-9, and a sample flow process chart is illustrated in figure 3-8.

Used in conjunction with these symbols, the following verbs may be applicable (see fig. 3-8.):

- ADD—to accumulate two or more quantities.
- SUBRACT—to take away one or a sum of quantities from the specific quantity.
- MULTIPLY—a short method of repetitive addition.
- DIVIDE—a short method of repetitive subtraction.
- RECORD—to place a generated element of data on the document being charted.
- COPY—to transcribe elements of data to the document being charted, usually from document to document.
- EXTRACT—to transcribe an element of data from the set of data being charted to another document.
- ERASE—to eliminate an element of data.
- COMPARE—to weigh the relations and/or condition of one factor to another. Compare is also used to locate a specific factor, such as stock number, serial number,

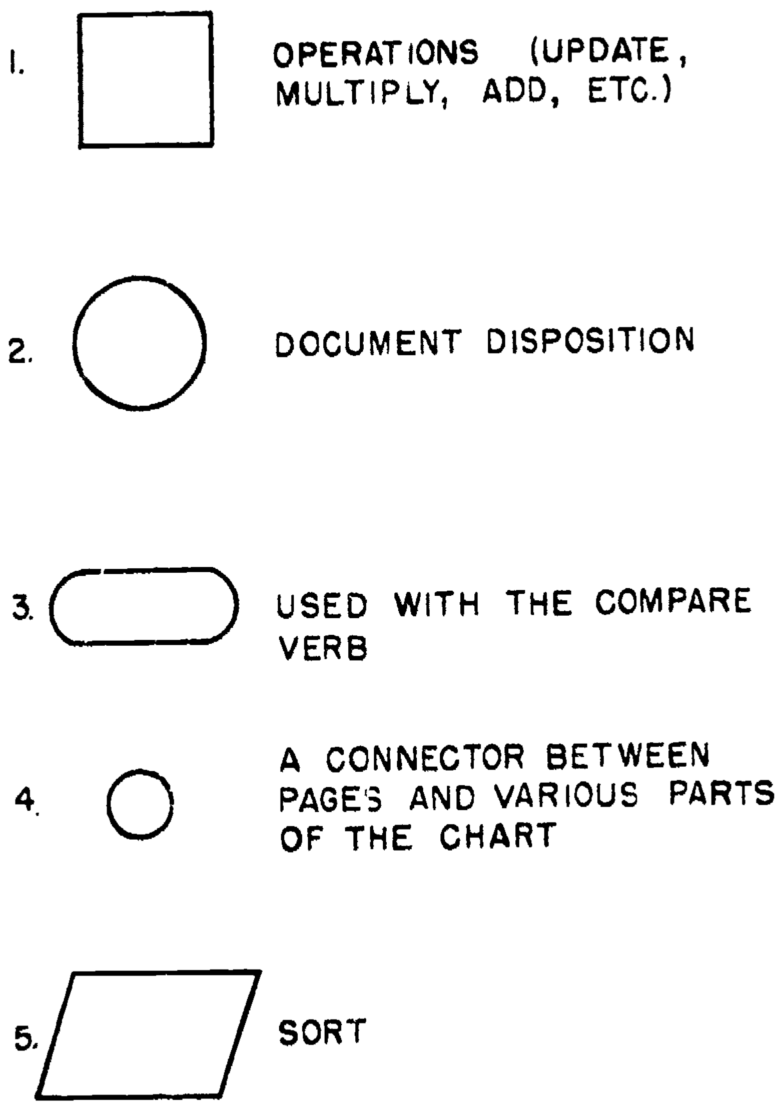

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Figure 3-9.—Flow process chart symbols.

et cetra. The following notations may be used with the compare verb:

1. $=$ EQUAL TO—one factor is equal to another.
2. $\neq$ UNEQUAL—factors are not the same.
3. $<$ LESS THAN—the first factor is less than the second.
4. $>$ GREATER THAN—the first factor is greater than the second.
5. $\leq$ EQUAL TO OR LESS THAN—the first factor is either equal to or less than the second factor.
6. $\geq$ EQUAL TO OR GREATER THAN—the first factor is either equal to or greater than the second factor.

These notations are representative conditions following a compare action.

- FILE—to store the document.

These verbs may be expanded or modified to meet the need of the user. However, each verb should be representative of one step in processing of elements of data through an operation.

Narrative Section.—Sometimes we have the need to present more information than can be shown in the flow process chart itself. When this occasion occurs, we have the narrative section (fig. 3-8) to help us expand our information. There are several conditions which may be reflected in the narrative section including:

1. EXPLANATIONS—to clarify items or actions which the member feels are unclear.
2. EXCEPTIONS—to describe unusual operations such as rejection of a document as a result of a comparison.
3. MULTIPLE SOURCES—when the necessary element of data is supplied for processing by more than one document.
4. AUTHORITY—when application of a signature is applied during processing.

If this document is considered for mechanization, it is necessary to describe this type of processing. When an authority must occur during processing in a mechanized system, ways must be developed to handle this special case.

SYSTEMS DESIGN

The purpose of our systems analysis was to enable us to design an optimum system within the resources available. Now that the present system has been analyzed in terms of output, files, input, and processing, we may begin to validate the system. Only after a specific system has been selected and processing has begun utilizing its capabilities, can the final degree of optimization be realized and the reliability of the system evaluated. However, in this text the optimization is expressed in general terms without regard to a specific computer.

AREAS OF SYSTEM DESIGN

The next step in designing a system is to determine what areas may be improved; these areas are discussed in the following paragraphs:

- End Products.—Intermediate documents and reports make up the end product.

• Elimination.—The intermediate documents may be done by the computer internally because these documents are used to facilitate data processing. So, the paper forms or punched cards which were formerly used to hold this information are no longer needed. The most common disposition for the intermediate document is elimination. Some reports may also be eliminated. This will be shown by the interview card already prepared with such factors as distribution, use of item, etc.

If a report can be eliminated, a check should be made to determine if any document which backs up this report can also be eliminated. An item check on the grid chart will show where other documents can be eliminated. In many cases although the report itself cannot be eliminated, some items on the report may be eliminated.

• Combined.—Sometimes by the addition of a few more items, one report can serve the purpose of two or more. Processing may be reduced if reports can be combined. An analysis of the elements of data on the grid chart can point out the possible combination of reports.

• Change in Frequency.—During the interview it may have been determined that there is a need to change the frequency of a given report. If this appears to be the case, a careful study of the input and file data, as well as the flow process chart must be made to determine if it is possible to change frequency of the document. New procedures for handling input and a change in the sequence of processing will probably be necessary for frequency changes.

• Change in Format.—A change of format may prove of value in bringing more important information to the immediate attention of the report user. Those items which require action may be prominently placed on the report, thus saving the user from wading through a vast amount of trivial but necessary data.

• Level Reporting.—With ADP, we can take a basic report and through successive eliminations and summarizations, develop many reports, each applicable to a particular level of management.

• Additional Items or Reports.—In some cases, additional items or even an entirely new report is vitally needed by management. The need for additional information may give rise to the need for an additional source document or a new entry in the file. Also the sequence of data processing may have to be modified or expanded to handle this additional requirement.

• No Change.—In the majority of instances, no change can be made to the output document report. This result is true when the report must go forward to a higher authority.

Once the end product has been analyzed, the results should be noted on the actual document. Also, the interview card should reflect the changes both as to the nature of the change and its effect on such items as workload and routings of the report.

SOURCE DOCUMENT ANALYSIS

The various changes discussed in regard to end product are not restricted to end product, but are equally applicable to source documents. Through proper analysis of the grid charts we may discover that we can eliminate certain items on source documents and, in some cases, entire documents. If the situation requires the addition of items or documents these must be reflected on the grid and flow process charts. If additional source documents are required we must develop procedures for their preparation, and establish new schedules. If the preparation of the source document is by ADP, we may wish to add internal information, such as:

- Transaction code
- Control data information

The type of files and processing which the source document must update are identified by transaction codes. For instance, is the source document an issue, receipt, or an adjustment? Quick access to files and routines may be ensured through the development of a simple transaction code. For control purposes this code should be placed on each source document, and may be preprinted for even greater control.

Control data information is used in source document preparation and conversion to maintain reasonable accuracy. Here again, preprinted numbers may be utilized as control data information to ensure completeness in receipt. As a safeguard against large errors, control totals may be developed in source document processing. In the case of control totals there should be certain restrictions imposed so that only certain types and amounts of information can be placed on the form.

All source document changes should be reflected on the grid and flow process chart, and in the workload statistics. If the source document contains multiple line entries, the workload should be broken down into two parts reflecting the number of documents and the number of transactions. Because hardware selection will determine the media and devices used, we will not discuss source document conversion here. But we should, however, determine where the documents are prepared and approved. There are important factors if the present systems conversion workload is to be determined.

FILE DESIGN

Data files cannot be permanently arranged until a specific piece of equipment (computer) has been selected. However, the files may be developed along functional lines. If the DP operation is of significant size, the data files will probably be in some form of magnetic storage. When the hardware is selected, it is the job of the analysts and programmers to develop the files within the specific systems capabilities. At this point in the analysis, it should be possible to firm up the files. For instance, those items which were eliminated from the reports should be removed from the file if they are present. After these eliminations an accurate picture of the workload should be presented. This may be accomplished by revising the summary card figures.

If we find that reports are being prepared from common elements of data, we may consider the possibility of consolidating the files. This would be depicted on the grid chart. At this point a determination should be made whether or not an uninterrupted flow of data from input to output can be developed. Can the files be arranged in such a manner that each input can be processed completely? The answer lies in the flow process chart which depicts documents which have processing common to more than one file. A procedure must be devised whereby a particular record may be pulled when it is required. The key to this operation lies in the transaction code and the sequence in which the records are arranged.

To develop the best arrangement of our files in terms of the job to be done we must determine what identification information (such as title, date, etc.) will be required on each file.

Finally, the contents of the new file must be edited to determine if all required reports can be produced from the file and if the data in the file can be manipulated to maintain current information for reporting, and that the file does not contain any element of data that could be produced by data manipulation.

Because of the relatively simple matter of saving data in the files of ADPs for future requirements, it may be desirable to analyze our grid charts for data elements which are available to the system on source documents which, because of the limitations of punched cards and the extra effort required in the manual system, have not been utilized for management purposes.

PROCESSING

This is the last area for consideration. Thus far, we have discussed input, output, and files and have seen how each of these areas is related to processing. In order to have a good working knowledge of the present system, we developed summary and flow process charts. We will not utilize these charts to aid us in the development of the new system. All charts for documents which will not be incorporated in the new system should be removed. Then those blocks which show processing of items which are no longer required for the new system may be removed. After these steps have been completed, the remaining processing should be carefully studied to answer the following questions:

- Can any processing be eliminated even without mechanization?
- Can any processing be eliminated by mechanization?
- Can some processing be combined? Grid charts are helpful in this area.
- Can the sequence of processing be rearranged, thereby reducing reporting time and further combining documents?
- Can the various functions of data processing be integrated so that we can make optimum use of the entrance of data into the system?
- Do additional management requirements necessitate editing of our processing?

We must schedule data so as to ensure that all processing is completed prior to the deadline for management requirements. In some cases the workload figures may have to be adjusted. At this point the flow process chart for the new system should be drawn. Now the new system may be described in detail utilizing the same verbs used for the existing system. Prepare the various frequency periods, such as a separate chart depicting daily, weekly, and monthly processing. When charting is performed in this manner, it is possible to determine if all data are available when needed, and coupled with volume will show the periods of peak workloads. Normally, a narrative and overall chart is prepared at this time.

At this point there are five conclusions that can be drawn:

- We know what input we must have.
- We know when it must enter the system.
- We know the contents and, to a degree, the files format.
- We know the new systems output requirements.
- We know what processing must take place to produce the required outputs.

CHAPTER 4

SYSTEMS DEVELOPMENT

In developing an ADP system, the sequential steps of identifying, analyzing, planning, implementing, and applying necessary administrative procedures should follow a routine which will ensure that all essential elements have been analyzed and that the equipment acquisition and employment are justified. Justification of ADP equipment is generally based on the following broad considerations:

- REDUCTIONS IN CLERICAL COSTS—The tremendous increase in paper work in many organizations has developed a greater need for faster and more efficient means of processing data.
- MANAGEMENT INFORMATION—Although ADP systems achieve clerical savings, this factor is secondary to the value of management information that is obtained from the system. The use of ADP equipment provides management with information that would be impracticable or too costly to derive under other methods.
- SCIENTIFIC MANAGEMENT TECHNIQUES—The installation of a computer provides new techniques in scientific management. It provides a basis for solving problems and assists in decision making for the optimum solution of problems.
- IMPROVEMENT OF SERVICE—The increasing volume of paperwork requires the utilization of modern, efficient techniques. The installation of ADP equipment provides a method of increasing the efficiency of an organization, resulting in improved service to users.

It should be clear that setting up an effective ADP system is a complex and lengthy job. A detailed and carefully organized plan for examining and weighing facts and opinions is necessary. Many policy and operating decisions must be made involving long-run commitments and therefore large amounts of money, for the costs of such commitments are likely to exceed the direct, immediate outlays for equipment.

It is desirable, therefore, that continuity of effort be maintained in conducting systems studies leading to ADP applications. Moreover, it is desirable that documentation of systems design and justification for application be accomplished in a uniform manner. The procedures discussed in this chapter will deal with the conduct of systems studies generally leading to the selection, acquisition, and employment of an ADP system.

A decision to establish a new ADP system or installation is reached in one or a combination of three ways:

- As a result of a favorable feasibility study
- Evolution from a punched card installation through natural growth
- By the rapid expansion of an existing data processing installation, resulting from changes in systems or volumes

In each of these cases, the steps in establishing a data processing organization are different. The development of data processing systems, as discussed in this chapter, generally reflect recognition in varying degrees, according to the nature of the equipment (if any) ultimately proposed, of the following major sequential stages:

- Feasibility study
- Application study
- Equipment evaluation and selection
- Detailed application and development
- Physical site preparation
- Conversion
- Post-installation evaluation

Each of these steps is discussed separately in the following paragraphs. It is important to note that application development, or indeed the entire process of data processing system development, does not or should not cease upon installation of equipment. Once initial applications have become an established operation, the attention of the operating activity should again revert to the feasibility phase. Thus, the entire cycle should be repeated as often as necessary to disclose other profitable applications as well as refinements in the prevailing system or associated equipment complement. Even if the initial mechanized system is quite advanced, the continued evolution of radical equipment developments and the ever-changing organization, mission, and functions of all activities compel periodic reappraisal.

Although the decision to develop a data processing system rests with higher authority, as outlined in SECNAVINST. 10462 series, Data Processing Technicians have had a hand in, and will continue to play an important role in, all phases of system development.

FEASIBILITY STUDY

A feasibility study is a study of the information requirements and data processing needs of an organization to determine what advantages, if any, would result from the use of automatic data processing equipment for stated applications, and which equipment would best meet those requirements. A study may generally be characterized as an overall reappraisal of the management information and data processing system requirements of an activity in an attempt to bridge the gap between what is thought to be best and what can be done economically. As such, it is an equally pertinent endeavor, whether the activity utilizes manual methods, punched cards, or electronic methods in its operations. As a matter of fact, a prime objective of such a study is the re-determination of the processing means most appropriate to the particular activity, with regard to both the changing information needs and missions of the organization, and the continuing data processing equipment, and associated technology development. In addition, it can be determined whether it is probable that operating economies or improved management effectiveness can be realized through the adoption of automatic data processing equipment or, if such equipment is not justified, through modification and improvement of the present system.

The command official having primary cognizance over the whole area to be studied usually establishes the study group, scope of the study, and reporting requirements, and makes provisions for the completion target date.

If a permanent organization with a mission to conduct feasibility studies does not exist, an "ad hoc" study group should be formed. A data processing feasibility study is intended and expected to cut across functional lines and pervade the entire organizational complex even as does the management information system it serves. The study group, therefore, should be made up of highly competent personnel, and should include knowledge of major functional areas within the activity, skill in systems analysis, and knowledge of the various methods, techniques and equipment.

If at all possible, participation in the study effort should be on a full-time basis, and it is essential that the designated leaders of the group serve on a full-time basis. With regard to the balance of the study group, it is generally preferable to provide for part time participation of highly competent personnel rather than full-time participation of more provincially oriented less competent personnel. Moreover, a brief but concentrated full-time effort is preferable to a prolonged part time study. The normal time requirement for completing a study is around 2 or 3 months.

A fundamental consideration in determining whether to use a computer is the adequacy of the present information system. The feasibility study concludes when the decision is made to convert or not to convert.

THE STUDY AREA

One approach to selecting areas for study is to start with the obvious targets for improvements, such as high-volume operations or repetitive operations that have a high clerical cost. These operations may by themselves justify the use of new equipment and a new system. The five major areas that must be considered in determining the objectives of a feasibility study are:

- PRIORITY—Determine the areas where the most benefits can be derived. That is, which applications should be applied to ADP equipment first.
- INTEGRATION—Determine all areas of administration which can be related intimately to the source data and the product data which will improve the management function.
- ECONOMY—Compare the cost elements with the benefits to be derived.
- OPERATIONS—Determine which machine characteristics are best suited to the needs of the administrative procedures. If the application is a secondary one, that is, the equipment determination was made for other applications, the operational determination should be that of how the operational procedures of the proposed

system can be adapted to the characteristics of the equipment available.

- EXPANSION—A most important consideration is the ability of the proposed system to be expanded to meet the mobilization requirements of the mission which the system supports.

Investigation

Since the above listed objectives affect the nature of the end product, the advantages and disadvantages of each objective must be determined. Investigation of the results of these objectives determines whether they are desirable.

Some factors to consider when choosing an area of data processing for detailed study are the history of the operation, experience with similar applications, expected benefits, personnel, resources, flexibility, and relationships of various areas.

Included in the study should be an all inclusive inventory of source documents, basic records maintained from them, and reports derived therefrom. This in turn, will decide whether data processing equipment should be applied. In addition, the study should identify and compile all significant cost data, including man-hour costs, categorized by major functions and/or organizations; these data are a requisite in a comparative cost analysis.

Analysis

The primary consideration for analysis should be the major proposed application for data processing equipment. The basis for determining priority may be cost, the time requirement, or the present state of mechanization. The analysis must be made in order to ascertain the best method of accomplishing the work; it must not be used merely as a vehicle for substituting an electronic data processing system for manual or mechanized systems. It should not be assumed that every function, every operation is essential; rather, each function and operation should be evaluated on its contribution to the accomplishment of the mission. The elimination of one or more reports, records, or operations may be the determining factor as to the type of equipment required, or whether an electronic data processing system is required at all.

Evaluation

An overall detailed examination and evaluation of the facts and of the flow process charts should be made to establish the basis for eliminating duplication, validating records and reporting requirements, and eliminating all unnecessary procedures and methods. Conversely, the addition of a process not being performed but which should be performed, and providing for essential records and reports not heretofore maintained, is considered during the evaluation. Definite conclusions should be reached about the relative suitability of EAM or EDPs for the purpose, and these conclusions should become the basis of recommendations to the official who directed the study.

Costing

Consideration of cost estimates should include, as a minimum, the following recurring and one-time costs:

1. Recurring direct operation costs, such as personnel, equipment rental, costs and maintenance of purchased equipment, and supplies.
2. One-time costs, such as:
   - Training programmers and machine operators
   - Programming initial applications and the testing thereof
   - Purchase of new forms and supplies, including magnetic tape
   - Applications studies and systems design for a specific project
   - Physical site preparation, installation, and related costs
   - Purchase of support equipment
   - Extra cost of parallel and/or pilot operations during conversion.

In addition to the estimates and records of recurring direct operating costs and one-time costs, estimates and records should be provided for tangible indirect savings, such as inventory reductions, resulting from more accurate and current information obtainable through improved data processing applications.

Present cost of operation and cost of performing the same operation as projected by the proposal should be set forth in the report of the feasibility study. These costs would include:

- EDP equipment, basic rental
- EDP equipment, extra rental
- EAM equipment, basic rental
- EAM equipment, extra rental
- Number and type of personnel
- Annual salaries, including overtime
- Supplies and other costs
- Contracting costs
- Present and proposed systems cost differential, showing cost carried over from present system and additional cost of the new system

FEASIBILITY REPORT

The final and written feasibility report should be submitted to management with its activities, findings, and recommendations. The report should be prepared intelligently and carefully with respect to all assigned objectives of the study, since they are the basis for developing a future ADP system. In addition, the report should include the following, as appropriate:

- Concise statements of anticipated benefits as a result of redesigning the ADP system, with special emphasis on their significance in relation to the management and mission effectiveness of the activity
- Precise statement regarding impediments to such redesigned systems that arise through compliance with regulatory or administrative practices imposed by competent authorities external to the activity itself
- Specific recommendations where deemed appropriate for redesigning systems and overcoming externally imposed impediments.

If, upon the conclusion of the study group, there is a high probability that either an initial substantially augmented investment in ADP equipment is warranted, the report should include:

- A brief factual description of the particular applications that appear to justify such equipment, with emphasis on the benefits of the proposed conversion
- A general indication of the type, size, and character of the expected equipment complement
- A summary cost analysis comparing detailed and actual benefit/cost relationship of the present system to the best estimate of the probable benefit/cost results of the proposed system.
- A definite recommendation regarding proceeding with the development of an application plan, with a timetable outlining the major steps in the proposed further development of such a data processing system.

Sufficient detail should be included in the report to permit a decision as to whether to authorize an applications study. Plans should also be included for starting an applications study that will develop a new system to achieve the estimated savings and that will lead to the equipment selection.

The report should be suitable for endorsement and forwarding by the local command official directly to higher authority.

APPLICATIONS STUDIES

Applications studies are careful, detailed extensions of the feasibility studies and should build on them. An applications study is defined here as the detailed process of analyzing existing procedures and mission requirements and redesigning a system or set of procedures for using ADP equipment for definite functions or operations, and establishing specifications for equipment suitable to the specific needs when equipment specifications have not been previously established.

One of the first steps is to determine which application areas are to be studied. It is necessary at this point to identify those areas with the greatest potential "before and after" difference in effectiveness, efficiency, economy, etc.

After determining basic areas for a study it is necessary to make a more comprehensive study of each application and carefully define the problems involved in each area. A problem, as applied here, may consist of an entire job, a portion or even a single factor of the job.

PROBLEM DEFINITION consists of finding out everything that is now known about the problem and how it is presently processed, plus everything that should be known, so that a practicable solution can be found for processing the problem with an ADP system.

Problem definition implies the existence of a problem. In data processing applications, a problem in its broadest sense is any major business function, such as payroll, inventory control, production control, and so forth. As such, it embraces all operations which are included in the overall function. In a more limited sense, a problem is any operation which is being investigated. Hence, if a function is considered as comprising a number of operations, the term PROBLEM can be applied to the whole thing or any part.

SCOPE OF THE STUDY

The development of an application study must not be undertaken until the feasibility report has been approved by the appropriate authority. This is to ensure the general reasonableness and validity of the class and range of equipment initially proposed, the maximum practical exploitation of all prior experience in mechanized data processing system planning, and the automatic provision of all possible assistance and coordinating effort. It also enables the appropriate official or office to plan and sustain a proper balance of programs and applications directed toward economic early use, best use, and pilot use of equipments.

The application planning group should ordinarily be constituted as a full-time "ad hoc" group. The group should represent skills and knowledge in fields similar to those suggested for the feasibility study group. The personnel selected should be highly competent in the areas of automatic data processing.

The sequential elements of an applications study are:

- Statement of concept
- System design
- Development of system specifications

Concept

The general nature and extent of the proposed system, and projected time-table broadly indicating the sequence of development and conversion will ordinarily have been provided by the feasibility study. Although higher authority has the responsibility of ensuring that the indicated approach and schedule are sound, reasonable, and realistic, the conclusions and intentions of the originating activity should generally be respected. Further, it can reasonably be expected that the higher officials will occasionally recommend or even direct modifications so as to preserve a proper balance of early use, best use, and pilot use efforts. In any event, the objectives, approach, and development schedule, with or without modifications incident to approval of the feasibility study, serve as the point of departure and overall guide for the applications planning group.

Systems Design

The paramount considerations in system design are to avoid unnecessary rigidity which might preclude taking advantage of the peculiar characteristics of certain equipments and to establish the feasibility of translating the available inputs into the desired outputs in an efficient manner. Among other things, this is the time to screen all data requirements to ensure that particular elements of data are introduced into the system only once.

Systems design may be divided into basic design and detail design. It is obvious that the basic design is the initial step. The critical review of data requirements continues into this phase, the ultimate goal being optimum systems design. Among many criteria leading to optimum systems design, three deserve special emphasis:

- The multiple use of common source data
- Organization of files for speed of reference
- Assurance that procedural instructions require only minimal repetitive use

An understanding of the general capabilities and limitations of proposed data processing equipment will provide a proper background to determine whether desirable end products are possible, and how the system must be designed to produce desired results and a well balanced system. The new system must be constructed in the form of schematic and flow process charts, and source document designs. Also, organizational, supervisional, and clerical requirements must be restated in view of the new procedure. While the assistance of customer service technicians is helpful and often necessary in the system design process, it should be remembered that systems design is the responsibility of the naval command concerned.

Development of Systems Specifications

Development of system specifications is the basis for competitive selection of ADP equipment. They must contain required information in sufficient detail to make the data processing requirements of an organization known to all interested equipment vendors. The specifications must be designed to insure full and free competition among all qualified vendors. These specifications are used to solicit manufacturers' proposals, evaluate their equipment proposals, and to select equipment.

Information, plans or justification that should not be disseminated outside the Navy, are of no concern to vendors and should not be included in the specifications.

The completed application plan report should be well documented and include the following minimal specifications:

1. A general description of the data processing needs of the activity in relation to the basic mission of the activity. Workload and employment statistics and any other information appropriate in describing the magnitude of the activity's problem in mission accomplishment and an organization chart of the activity showing the location of the proposed EDP function.

2. Clear and precise narrative indications of the nature and scope of each application, supplemented by general flow charts. The following data should be included for each application in sufficient detail to permit timing and selection of equipment:

- A description of the content and purpose of proposed outputs.
- A description of the content and source of all input data.
- Record lengths and number of records.
- Processing frequencies.

3. Narrative description of applications performed under the present system which correspond to proposed applications, including general flow charts if required for clarity and brevity.

4. Definite indications of the benefits that are expected to accrue to the proposed system that cannot otherwise be attained, and justification of these benefits in terms of economic gains or improved management effectiveness.

5. Detailed comparative cost data for the proposed system and the present system, adjusted by improvements developed during the study, but not entailing initial or augmented equipment installation.

6. Indications of personnel implications in terms of reduced or augmented staffing needs.

7. Indications of the availability of and expected cost of site preparations.

8. For EAM proposals only, an itemization of the proposed equipment complement with details of anticipated machine workloads. Also, where the proposal relates to augmenting an existing equipment installation, the monthly utilization of all equipment presently installed should be presented for the most recent typical quarter, and new workloads, or increased volumes of old workloads should be documented.

9. For EDP proposals only, a projected schedule should be provided covering plans for equipment selection, detailed application development, personnel training and orientation, site preparation, installation, transition, and attainment of normal operations. Subject to approval of the application plan by the reviewing authority, this schedule will be the basis for introducing the proposed project into the Navy's Data Processing Support Program for review and approval by the Assistant Secretary of Defense (Comptroller). In addition, a summary discussion of the consideration given to random versus batch processing, with detailed substantiation of any proposal entailing random type processing methods or equipment. Similar documentation should be provided with respect to source data automation and high speed communication facilities, as appropriate.

After completion, the applications plan must be submitted to the bureau or office maintaining management control over the submitting activity for review and approval.

EQUIPMENT EVALUATION AND SELECTION

An essential phase of an automatic data processing systems study and development is the proper evaluation of all commercially available equipment with the result that final selection is in the best interest of the Navy.

In evaluating equipment, all qualified sources of supply must be considered, and equal opportunity, facilities, and information must be made available to each potential supplier. There is no requirement however, to consider any equipment that does not exist in at least a prototype form. If an otherwise qualified manufacturer cannot deliver equipment by a specified date, such equipment may be excluded from further consideration. On the other hand, if a qualified manufacturer is unable or reluctant to make a specific proposal, the Navy is not absolved from its responsibility for considering that particular equipment.

It is essential that selection from among competitive equipment systems be made by Navy personnel. This does not however, preclude the use of freely volunteered services of the manufacturers concerned, since they can generally supply all necessary details with respect to such things as capabilities, costs, contract terms, and feasible delivery dates of the equipment they manufacture. Activities are free also to avail themselves of the assistance of data processing specialists in the parent bureau or management office and the Administrative Office of the Navy Department in the course of equipment evaluation and selection.

Logical development and clarity of expression have compelled the recognition of specific stages in the design and implementation of DP systems. Equipment evaluation and selection is a distinct phase, separating application planning from detailed application development. However, in actual practice, it is fully expected that the application plan will be modified by the equipment evaluation process, even as the former will influence the equipment selection. The application planning and equipment selection phases are so mutually inter-dependent as to entail a "ping-pong" process, wherein a decision regarding one immediately influences the other, until a clear indication of the most appropriate equipment complement finally emerges.

Controlling factors in the selection of one set of equipment from among various equipments capable of handling the proposed workload are TIME and COST. Factors which cannot be reduced to these terms are permissible only when time and cost factors are not conclusive. It is Navy policy not to standardize on any particular manufacturer's equipment currently available or foreseeable.

Subject to the foregoing general policies, the following procedure is prescribed by the Secretary of the Navy for the selection of electronic data processing equipment:

- Detailed time-cost estimates relative to each potentially acceptable equipment complement shall be developed. These estimates should normally be prepared by Navy personnel, and may or may not be supplemented by estimates provided by equipment manufacturers. In any event, it is essential that all estimates be derived on the basis of the same assumptions and workload details. Estimates of equipment manufacturers, when considered, must be carefully validated by Navy personnel to assure that they are based on comparable considerations.
- Cost estimates should cover all expenses to be incurred in the installation and operation of the proposed system, including such recurring costs as personnel, equipment rental, maintenance of purchased equipment, and supplies. Include also one-time costs, such as applications studies and systems design, programming and debugging of initial applications, training of programmers and operators, new forms and supplies (including purchase of magnetic tapes), site preparation and equipment installation (with related costs), extra cost of parallel operations during transition, and purchase of auxiliary equipment such as filing cabinets, carbon separators, and so forth.
- Timing estimates should cover average daily processing times, process cycle times (when it is important that certain functions be completed within a certain elapsed time), and an indication of the available extra capacity. The latter determination should take into account the speed of the equipment as well as unused time.
- The field of potentially acceptable equipment should then be narrowed on the basis of significant disparities in machine capacity. In this regard, the capacity of the ultimately proposed equipment should reflect a reasonable balance of utilization and reserve capacity for future expansion. Thus, equipments which would entail almost a three-shift operation to accommodate the foreseeable workload need not be considered further. On the other hand, equipments which would entail substantially less than one full shift to accommodate the foreseeable workload should not normally be considered, unless such minimal use can be justified on the basis of direct economic gains not otherwise attainable, or unless they provide some unique feature or capability not otherwise available which is essential to the proposed applications.
- Cost data should be taken into consideration only after the field of potentially acceptable equipments has been narrowed on the basis of use and reserve capacity requirements.
- Subject to exceptional considerations dictated in particular circumstances by the appropriate bureau, command, or office, other factors should not normally be introduced into the evaluation of equipment unless the results of an analysis of time-cost factors do not conclusively indicate the superiority of one specific equipment complement. In such cases, the additional factors should be translated into time or cost indications wherever possible and their use substantiated.

It should be pointed out that no activity is obliged to inform any manufacturer regarding either the equipment selected or the basis for equipment selection. Further, all activities are encouraged to refrain from publicizing such information before final approval of the selected equipment.

Particular attention is required when considering the difference in contract terms offered by competing manufacturers. Considerable cost advantages are available under certain contracts which are lacking in others. It is important that these differences be taken into account when making the equipment selection.

The frequently appearing factor of "compatibility," must be treated with care. This term in its reducible form is time and cost. Proper compatibility is important and essential to any organized effort or effective information system, but there are no cut and dried methods of achieving it. For example, one EDPM can be made compatible with another through effective use of peripheral equipment. It is not in the Navy's overall interest to make successive selection of equipments, each inferior in time/cost competition with previous selection, simply to be compatible. If there is a requirement compatibility between elements of the Navy, each element involved has equal responsibility for it. Whatever requirements for direct "compatibility" are incorporated into equipment selection must be thoroughly sound, demonstrable, specific, and the result of careful analysis, consideration of all alternatives, and an evaluation of the current competitive time/cost position of the other equipments with which compatibility is desired.

BENCHMARK DEMONSTRATION

To facilitate evaluation of the equipment configuration and software proposed by each vendor, several representative processing tasks are normally designated as "Benchmark Problems." Each interested vendor must demonstrate his capability to successfully run these problems. Since it is normally not practicable to require each vendor to program the entire data system, the importance of selecting appropriate benchmark problems cannot be overemphasized. Properly selected benchmark problems will ensure that the most complex types of processing can be accomplished. They will ensure that adequate memory input/output devices are included; that throughput speeds are attainable to do the entire job; and that the software proposed is operative and adequate.

The benchmark problem(s) should emphasize any new type processing or special components, such as remote stations, dynamic display devices, etc., that are not in common use or which represent advanced technology or techniques. The benchmark demonstration also provides the selection agency with actual timing data upon which to base overall evaluation.

DETAILED APPLICATION DEVELOPMENT

This phase in the development of a data processing system relates to all detailed efforts required to translate the general applications plan and equipment selection into a complete and practical operating reality. These efforts essentially include:

- The staffing, organization, and training of personnel.
- The readying of the installation facilities.
- The detailed planning, testing, and debugging of all initial application routines.
- The development of detailed documents relative to desk procedures, data clean-up, file conversion, and machine loading.
- The schedules covering transition, parallel operations, normal operations, and the release of excess billets and displaced equipment.

While detailed training toward the operation and programming of specific equipment is initiated at this point, general training and orientation are continuing efforts which should begin with the first indication of the feasibility of mechanization, and which should be well under way prior to equipment installation. In this regard, training should not be confined solely to potential data processing personnel, but should be extended as necessary to apprise all personnel concerned of the scope, implications, and expected benefits of the proposed system and associated equipment.

Pre-Installation Survey

In lieu of a formal report for the detailed application development an on-site readiness survey by the appropriate officials will be conducted to ascertain the adequacy and completeness of this phase. These surveys are normally scheduled for approximately 30-60 days in advance of the tentatively scheduled equipment installation date.

The establishment of a firm installation date will be contingent upon readiness survey indications that:

- The staff is on board and trained.
- The operating programs for initial applications are or will be tested and debugged by the scheduled equipment installation date.
- A realistic schedule for conversion is available, including parallel and phased loading operations.
- The site and supporting services will be ready, by scheduled delivery date, to accommodate the equipment.
- A valid record system is established for effectively measuring the before and after cost/benefits.

The latter should be presented in a form that compares current estimates with feasibility study and application plan estimates, and which explains discrepancies therein; and should be in such detail as will enable an evaluation of actual performance approximately 1 year after the equipment is installed.

It can be expected that the survey will place considerable emphasis on a review of proposed transition procedures. Experience has proved that associated problems are generally underestimated by the operating activity. All processes which do not take place exclusively within the data processing equipment must have detailed desk and operating procedures and schedules. These should include:

- Run books with operator instructions for each initial application
- Written procedures for data clean-up and file conversion
- Loading schedules showing initial build-up by component and application
- Practices to be observed during parallel operations
- Schedules for file conversion, parallel operation, equipment and billet release.

PHYSICAL SITE PREPARATION

The establishment of approved ADP installations or the expansion or relocation of existing installations requires thorough planning and definite preliminary actions prior to the actual installation of ADP machinery and associated equipment.

The site facilities required for the installations where equipment is to be operated should be researched early in the planning stage. This is necessary to provide sufficient lead time in case a construction project needs to be initiated and to effect funding for site preparation.

The user or customer of the specified equipment has the responsibility for the work encountered in the site preparation. Normally, this work is performed by general contractors and is not considered part of the equipment purchase, lease, or service contracts.

Because the specific details of installation are complex and involve a wide range of technology, it is strongly recommended that only qualified and experienced personnel be utilized for planning and designing the installation facilities. The successful installation of an ADP system involves various services and/or contractors. For the most efficient site preparation, site design work must be handled by professional engineers and architects and the construction work must be performed by qualified electrical, mechanical, and structural contractors. It is necessary that the customer appoint someone qualified to supervise and coordinate this effort.

The following paragraphs do not enumerate all the areas of site preparation but cover in general terms the planning and action necessary to establish an installation.

SITE REQUIREMENTS

Preparation for the ADP site should be started in sufficient time to allow for its completion at least 60 to 90 days before the system is delivered. Air conditioning, humidity control, uniform power supply, heat dissipation, floor loading, tape storing, and a central location are among the most important considerations when planning for the ADP site. Ample room must be allowed for every component.

Floors and elevators must be strong enough to support the equipment. Door and corridor widths must allow for movement of ADP equipment components into the site. A working area for service engineers is normally required in or adjacent to the ADP equipment site area. Site preparations should insure satisfaction of vendor facilities specifications as well as providing ample room for the needs of Navy operating personnel.

FACILITIES SPECIFICATIONS.—Each equipment vendor provides installation manuals containing detailed specifications for each type of data processing system. As soon as the specific equipment has been selected, the contracting agency should be provided with the information necessary to begin construction in time to complete site modifications by the prescribed target dates. It is advisable to have an engineer of the data processing equipment manufacturer review the modification plans and inspect the actual site modifications periodically.

POWER AND AIR CONDITIONING.—Power requirements may vary with each make and model of equipment. Additional power and air conditioning may be necessary for support equipment. Heat dissipation in some areas must be given special attention. Close coordination with the station engineer and vendor are essential to insure that proper power and air conditioning are provided.

COST AND APPROVAL.—Justification for the construction program and other budget programs must identify the cost which will be incurred in site preparation and must contain sufficient detail for review at all levels of approval. Consideration should be given to the use of existing facilities, the modification of existing facilities, and the need for new facilities, in that order. The following list includes those items which must be normally considered during site preparation:

1. Floor Plan:
   - Layout for ADP equipment, furniture, auxiliary equipment, cabinets, partitions, windows, tape vault, etc.
   - Building location
   - New construction requirements
2. Temperature and Humidity Requirements:
   - Air conditioning
   - Heating
   - Humidifiers
   - De-humidifiers
   - Blowers
   - Plumbing
3. Electrical Requirements:
   - Current
   - Voltage
   - Frequency
   - Phase
   - Convenient Outlets
   - Lights
   - Transformers
   - Regulators
4. Adequate Space for:
   - Tables
   - Desks
   - Chairs
   - Carts
   - Card cabinets
   - Tape cabinets
   - Supply cabinets
5. Fire Protection
6. Future Expansion of the System.

Floor Loading

Most office buildings will sustain the weight of ADP equipment. To determine if the floor is adequate, allowable floor loading and structural configuration of the floor should be investigated by qualified personnel.

A floor capable of supporting a load of approximately 200 lbs. per square foot should accommodate all EAM and related equipment. EDP requirements may be determined by consultation with the equipment vendor who will provide the weight and floor loadings.

Raised Flooring

Most computer systems are designed to be installed on a raised-type floor with a clearance between the subfloor and the bottom of the raised floor sections. The space under the raised floor permits cables to be run directly, in a relatively straight line between equipments, and provides maximum flexibility of equipment layout, ease of installation, neat appearance, and personnel safety.

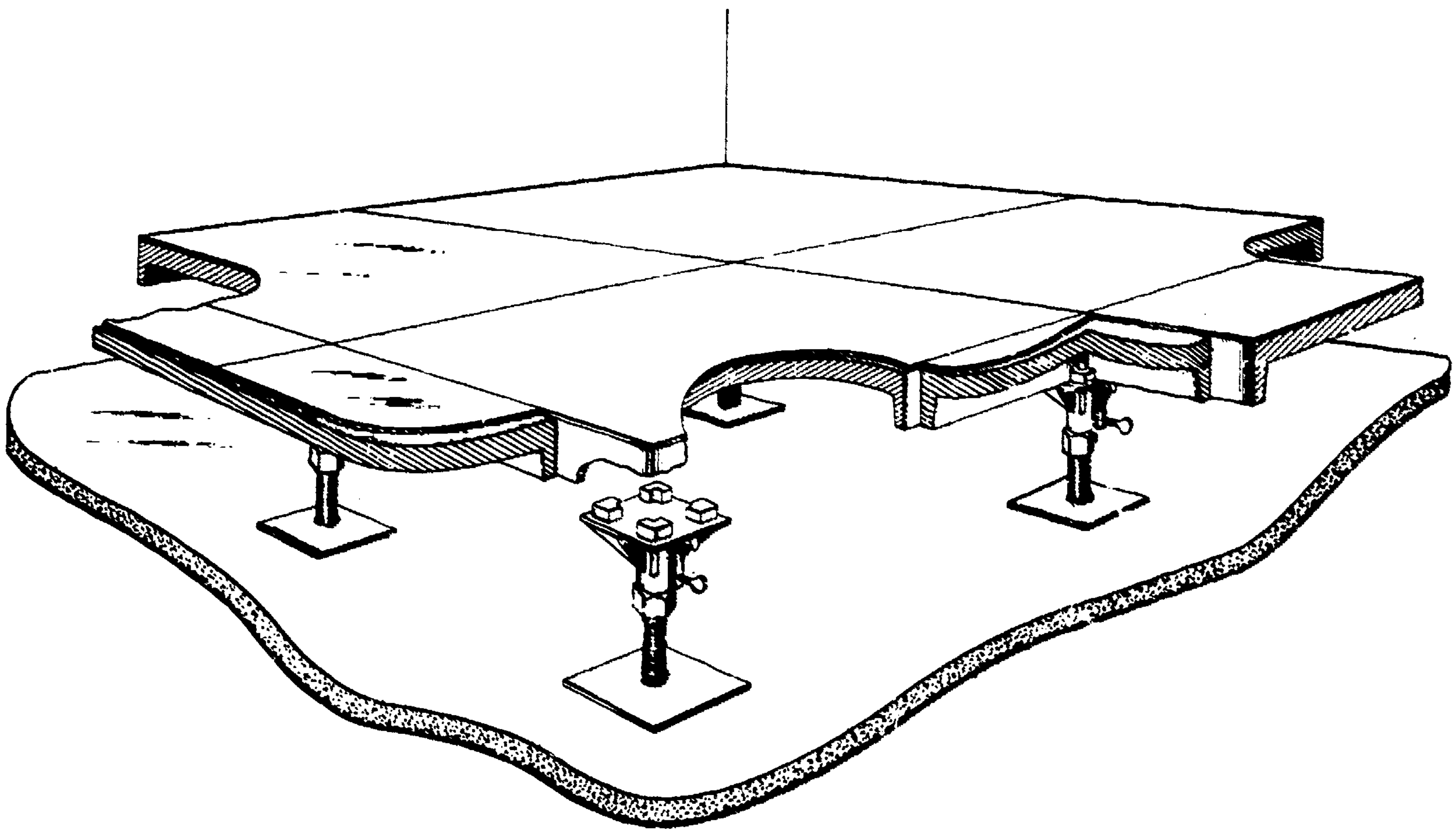
To guard against safety hazards for personnel and cable damage, a suitable protective arrangement must be installed when raised flooring is not used and surface wiring is employed.

An illustration of how a typical raised floor is constructed is shown in figure 4-1.

Hazard Protection

In most cases local codes establish the protection required for computer systems. This information is generally outlined in the applicable building and electrical codes.

Portable carbon dioxide (CO_2) fire extinguishers should be located in readily accessible locations within the equipment area. A central type CO_2 fire protection system may also be



78.100X

Figure 4-1.—Raised flooring layout.

used. Soda acid, foam, and other wet-type fire extinguishers are ineffective and hazardous to equipment and personnel. A fire detection and alarm system may be installed in the equipment area. Commercial detection systems are available that detect heat, smoke, and water.

The equipment vendor must be notified if it is necessary to alter the equipment in order to comply with local codes.

Acoustics

No acoustical problems are normally encountered through the use of electronic units such as the computer and tape stations. However, mechanical I/O devices such as card readers, card punches, printers, and blower fans in the electronic racks are sources of noise; therefore, the proper selection and use of sound-insulating materials is advisable. Such treatment may be accomplished through the use of acoustical materials on ceilings, floors and walls during construction. Existing sites may also be modified by application of acoustic materials including lint-free drapes.

Illumination

The lighting in most offices will suffice for a normal installation. About the only special requirement for lighting would be in a large EDP system where the intensity of the lights would hamper console operations. Here the lighting should be so connected that the intensity may be lowered for ease of viewing the console lamp indicators.

Emergency lighting should be provided where necessary to protect personnel and equipment against a sudden failure of lighting. Areas to be especially considered are those where equipment controls are located.

Layout

The physical layout of an EDP system not only must satisfy the present and future requirement for the proposed use, but must be correlated with the user's operational requirements. The layout should be integrated with other related areas for the most efficient flow of work. The equipment placement should satisfy the interrelationship of the equipment, cable length limitations, and provide space around the units for operation, maintenance, and normal traffic. In addition, the areas to be used by the maintenance and supervisory personnel should be appropriately located. A typical EDP system layout is illustrated in figure 4-2.

CONVERSION

One of the major problems confronting an installation is the problem of conversion. The term conversion could be applied to almost any transition from one method to another. It could apply to converting from manual bookkeeping to a machine system, from bookkeeping machine to punched card, from one machine system to another machine system, etc. The term CONVERSION as applied to computers is generally used to denote a change in the method of processing an application from some other system (manual, EAM, etc.) to a computer system. It can also refer to changing from one computer to another, such as from a card orientated computer to a tape or disk system, from one size computer to a larger size computer, from one manufacturer's equipment to another, etc.

Conversion involves an orderly process whereby changes are made from old procedures to new procedures. Even though the problems may not be encountered until after installation, conversion plans should be made well in advance.

METHODS OF CONVERSION

During the system design phase plans are made to determine which approach is to be taken in the conversion process:

- Parallel operation
- Pilot installation
- Direct installation

No matter which approach is adopted a realistic conversion time schedule should be developed, based not only on the equipment and personnel, but also on the amount and type of work to be done as well.

Additional personnel and/or equipment may be needed on a temporary basis to complete preparations for conversion. The job of converting each application should be assigned as a specific responsibility. Some of the specific tasks involved in a conversion operation are listed below:

- Gathering the data required for the master files
- Editing the files for completeness, accuracy, and correct formats
- Creating new files, and procedures to maintain them, until they are used in production runs
- Provision for training machine operators and personnel in the departments that will supply the source data and receive processed data from the DP system
- Establishing the schedule for cutover to the DP system
- Planning for conversion operation
- Coordinating the actual conversion process
- Cross-checking the results of processing by both systems (old and new).

If the preparation for conversion is properly carried out, the conversion itself should occur without difficulty. The following paragraphs discuss the basic types of installation plans for conversion to an EDP system.

Parallel Operation

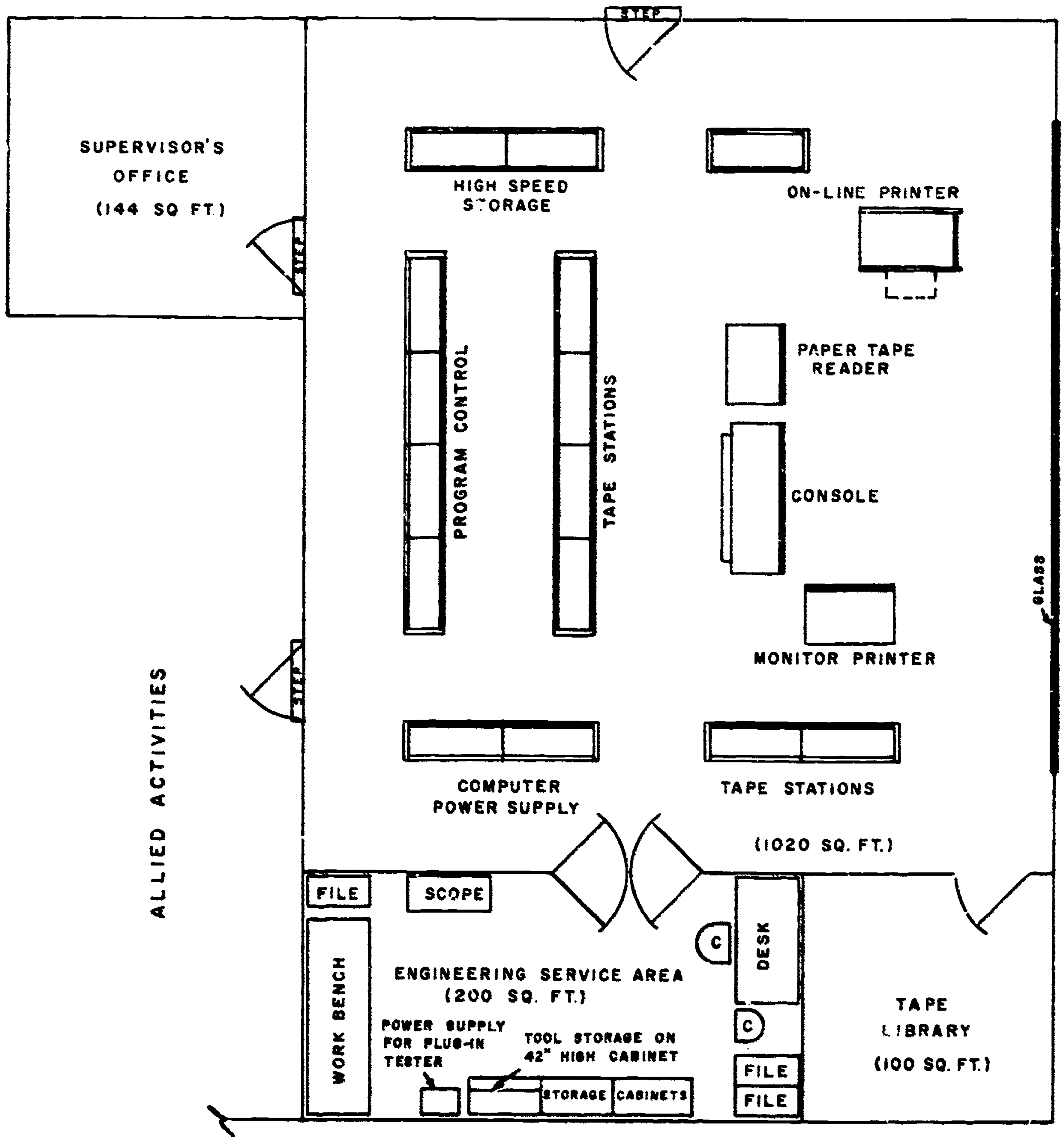
Parallel operation involves processing of current data by both the new system and the old system simultaneously. Parallel operations are usually continued through one complete cycle of processing (for example, an accounting month). Parallel operations allow a comparison of the new results with the old to determine the accuracy of the new output.

Although parallel operations are considered essential by many individuals, such operations are expensive and place a strain on the operators by requiring the two systems to operate concurrently.

Parallel operations are normally recommended for projects which require processing in which there is little room for error. Any major system change should normally use the parallel plan of installation.

Pilot Installation

If the new system is extremely complex it may be desirable to try a pilot installation approach. With the pilot installation approach, the DP system is immediately put into operation on a full-volume basis, using the data from a previous period. In the meantime current data can be processed by the old procedure. The



78.104X

Figure 4-2.—Representative EDP system layout.

results of the DP system can then be compared with the results of the old procedure for the prior period. Output can be checked for accuracy, completeness, and proper handling. This approach frequently reveals deficiencies which provide valuable information, and any necessary adjustment to the new procedure can then be made.

Basically, what is being accomplished is a testing of the new procedure. Such an approach provides valuable operating experience with the new system, since complete application are run under much the same conditions as will be encountered in actual production runs. In addition, other personnel have the opportunity to prepare input to the DP system.

Pilot processing tests the entire operation of an application from start to finish and allows a refinement of the details of a complex procedure.

Direct Installation

Direct installation involves conversion from the old to the new system all at once. A date is selected after which all procedures under the old system are replaced by the new system procedures. Using this approach, the new system is debugged using "live" data and the old procedures are completely abandoned.

The direct installation method is normally recommended when the procedures and volume of transactions are not as complex.

CHAPTER 5

DATA PROCESSING TECHNIQUES

The previous chapter described some of the essential planning factors to establish and justify the ADP organization, equipment selection, site construction, and conversion planning. The data processing techniques discussed in this chapter are also primarily concerned with preinstallation. That is, they are the techniques and methods to be considered immediately after the order has been placed for any new or original ADP system.

Some degree of preparation is necessary for the installation of even the simplest type of ADP equipment. Planning for the use of the equipment must be accomplished to insure a maximum degree of readiness to permit early productive use of the equipment. To achieve that goal, the using organization should initiate plans and implement actions for installation well in advance of the ADP equipment installation date. The planning must take into consideration the requirements for personnel acquisition and training, applications to be developed, and procurement of other resources which are necessary to effectively use the ADP equipment. The information presented here is not intended to be the only means of effecting an ADP installation, but is merely offered as a guide.

PERSONNEL REQUIREMENTS

The personnel requirements by skill level for operation of the ADP installations planned should be carefully calculated. This requirement for technicians to support the ADP system must be based on a detailed and comprehensive study of planned applications. The requirement for systems analysts and programmers will present the greatest problem, because the need for them will be governed by the extent to which the applications are to be implemented at any given time. The requirement for operators can be determined after the equipment requirements are developed.

BILLET CLASSIFICATIONS

The responsibilities of an ADP manager are varied in number and great in magnitude. Without a thorough knowledge of the technical details and skills used in data processing, supervision can become very difficult. YOU, as the senior man, may control the entire computer center.

Your responsibilities as an ADP manager will be discussed in later chapters of this text, but first, let's discuss some of the personnel requirements of any ADP installation. While no standard organizational or staffing pattern can be safely decreed for all installations, the following types of personnel are normally needed to make full use of an EDP system.

Systems Analysts

The analyst analyzes existing and proposed systems and optimizes them to efficiently utilize, through programming and clerical steps, the capabilities of ADP systems. This involves identification of the input, segmentation of the system into components where ADP systems would apply, identification of the workload, identification of the products and development of procedures and formulae for each specific step in the system.

Programmers

The programmers, working from the analysts' specifications, design the data flow elements of each step into detailed block diagrams which, by symbolic representation, provide transition from the more general systems flowcharting to the specific techniques necessary to represent the program logic. This block diagram is then utilized to translate the logic into correct codification to develop the computer instructions.

Operators

The operators supervise or perform operation of the system and its component items of equipment. In some cases they must analyze machine stoppages to determine whether cause lies in the program, the input data, or is due to faulty equipment.

Maintenance Personnel

Navy maintenance personnel may be required for shipboard, remote, or highly sensitive locations to perform preventive and corrective maintenance.

SELECTION AND TRAINING OF PERSONNEL

As a new Navy installation is planned the personnel are normally assigned by the Bureau of Naval Personnel, Washington, D.C. ADP personnel are selected on the basis of previous experience, past performance, educational qualifications, leadership potential, capability for growth, specific aptitudes for data processing, and sea/shore rotation.

The size and scope of the ADP system should determine the training that must be planned and organized. All the personnel assigned may not be familiar with the type of equipment scheduled for installation. The training of ADP personnel constitutes an important phase in preparing to use ADP equipment.

Capable personnel are necessary for performing effectively the functions of systems analysis, programming, equipment operation, equipment management, tape handling, and all the various other tasks required for system efficiency. The success of the installation will depend, to a large extent, upon the training of all personnel assigned. The following paragraphs discuss some of the frequently used training methods

FORMAL TRAINING

Formal classroom training is imperative for technical trained personnel, and it is essential that the personnel involved receive the training required to implement the proposed system. It is a must for developing technical skills in the areas of programming, system analysis, operations, managing, and supervision. Included in classroom training would be detailed instruction for the operation and application of each piece of specific equipment in relationship to the job requirements of the installation. This training is available for most computer systems at the DP schools.

Vendor Schools

The manufacturer of the ADP equipment selected usually provides facilities for training technical personnel in the programming and operation of equipment.

Courses at the executive level introducing computer concepts to top management are also frequently given and provide an effective means of educating management personnel.

Arrangements for instruction at vendor schools usually are made through the local sales representative. The cost of this training varies depending on the course and vendor.

ON-THE-JOB TRAINING

Generally, personnel completing classroom training will have the basic working knowledge and skill to perform their specialty. This basic knowledge and skill must be enhanced through job performance and a carefully planned and executed OJT program. A tape librarian, for instance, will normally be concerned only with the procedures used in maintaining the tape library. But, to enable him to communicate intelligently with others he must have sufficient training on the EDP system and application.

Likewise, a console operator will normally require a programming course on the system, and should be required to write a small program or portion of a program.

The job can be either that of the present or some future assignment. In some cases the job is of a higher grade than the man's present one; in other words, you are preparing the man for advancement. The makeup of OJT takes many different forms including lectures, practice on machines, special assignments of a temporary nature, and job rotation.

ORIENTATION OF OTHER PERSONNEL

In addition to the training required for your own shop, you must take into consideration the indoctrination of personnel in other departments. This is especially true for those departments whose procedures affect, or are affected by the ADP system. This indoctrination would be concerned with the various methods of arranging data, or with the addition, deletion, preparation, and disposition of data. The new procedure must be clear to all personnel who will be working with them.

PLANNING AND PROGRESS CONTROL

After an order has been placed for a particular system, an extremely crucial period begins between two dates, the order date and the installation date. A planning schedule should be prepared and used as a master guide to insure that the transition will be smooth and on schedule.

Due to the many requirements involved and their magnitude during the installation of an ADP system, it is necessary to carry out a variety of tasks simultaneously. Therefore, these activities must be carefully planned and developed insofar as possible by the ADP manager. Naturally, changes will be encountered as detailed studies and programming get under way. To meet the date set for completing the installation, it is often necessary to establish frequent reviews of progress to ensure that the whole program moves forward in a strictly controlled and orderly fashion.

In planning and progress control the three types of schedules listed below will be found helpful:

- General preinstallation
- Application development
- Program development

GENERAL PREINSTALLATION SCHEDULE

As was mentioned earlier, a schedule to control overall progress toward meeting the installation date is essential. These schedules also establish target dates for the major activities of establishing the ADP organization, initial education, program development, conversion planning, and physical installation planning.

The sample preinstallation schedules that are illustrated in this text are not the only forms that could be used. Nor are they in a format that would fit every application. They were selected at random and are used as examples only.

In figure 5-1 the schedule is broken down into major sections. This schedule is completed by the installation manager and the representative of the equipment manufacturer. The Estimated (Est.) Lead Time for starting prior to delivery is recorded in months. The section labeled Starting Time allows for recording the estimated starting time as well as the actual starting time. Other schedules are illustrated in figures 5-2 and 5-3. You will note that these forms have some details that do not appear in figure 5-1, but are essentially the same. The forms shown in figure 5-2 and 5-3 are intended to provide a comprehensive schedule for all preinstallation activities. The user of these forms may prefer one or the other, or he may prefer to consolidate them. In either case, they do serve a useful purpose. The schedules shown in figures 5-4 and 5-5 are more restricted in their scope. Each applies to a specific preinstallation problem. Notice that figure 5-4 deals only with site preparation; whereas figure 5-5 deals only with initial education.

Figure 5-6 illustrates a preinstallation schedule report. This report should be prepared each month during the preinstallation period. It is forwarded to the ADP manager and the company's representative for review and is used in monthly progress reviews with top management.

This report serves a dual purpose—the upper line contains any change in progress to date—the lower line contains progress to date. Whenever any section of the schedule falls behind it is flagged in the action section. Action notes are not required provided the preinstallation schedule does not fall behind. However, in the event that the schedule is falling behind, corrective action must be taken at the time of the monthly progress review. This action could include working overtime, or assigning additional personnel.

APPLICATIONS DEVELOPMENT SCHEDULE

A helpful chart in preinstallation activities is the Applications Development Bar Chart (fig. 5-7) which shows an overall picture of programming progress.

All programs are listed vertically at the left of the chart. It is convenient to group them by application. Calendar periods are indicated across the top of the chart, starting with a date prior to delivery and ranging up to or after the delivery date. The nature of the program and the DP system will determine the length of the periods and the total amount of time involved.

Two horizontal rows are provided for each program. They serve as a comparator. That is, the top bar representing the planned schedule and the bottom bar representing the actual schedule.

As work proceeds, planned dates will sometimes turn out to be unrealistic. Caution should be exercised at this point because it is desirable that these estimates be revised. However, when the revision is made a new chart should be developed. The new chart will reflect realistic expected completion dates. The old ones should

PREINSTALLATION SCHEDULE			
	EST. LEAD TIME FOR STARTING PRIOR TO DELIVERY (NO. OF MONTHS)	STARTING TIME	
		EST.	ACTUAL
ESTABLISH DATA PROCESSING ORGANIZATION			
A. APPOINT SENIOR IN CHARGE	13		
B. SELECT PROGRAMMERS	12		
INITIAL EDUCATION			
A. CLASSROOM	13		
B. ON-THE-JOB TRAINING			
PROGRAM DEVELOPMENT			
A. DOCUMENTATION	12		
B. CODING	10		
C. TESTING	8		
PHYSICAL INSTALLATION PLANNING	4		
A. ROOM LAYOUT			
B. CABLE ORDER			
FIRST TEST SESSION	7		
ESTABLISH CONVERSION PROCEDURES			
A. MAJOR APPLICATION PROGRAM TESTED			
B. PILOT RUNS-PROCEDURES AND CONTROLS			
FINAL DETERMINATION OF EQUIPMENT REQUIREMENTS AND DELIVERY DATE	4		

Figure 5-1.—Sample preinstallation schedule. 78.50X

be retained as a historical record. The retention period varies so widely from one activity to the other that you must consult local directives to determine the appropriate period in each case.

Each horizontal bar can be color coded, if desired, to represent different phases of program development (see Legend fig. 5-7).

The Bar Chart provides a compact, overall view of planning and progress. In addition to the Bar Chart it is well to maintain more detailed records of progress. These records have a twofold purpose—they facilitate frequent evaluation of progress and provide a detailed record of experience which is valuable in future planning.

Figure 5-8 illustrates a form for recording program progress. This form could be submitted for review by each programmer on a weekly basis. The activities listed in the figure could be subdivided into more detailed steps if desired.

The Record of Progress Chart (fig. 5-9) is composed of information from the Bar Chart and the Weekly Record of Program Progress Chart. The application programs are listed down the left side of the form and the associated activities are listed horizontally across the top. Here again we have the predicted and actual time as well as the percent of completion (% comp).

PROGRAM DEVELOPMENT SCHEDULE

The Program Development Schedule can be used as both a working checklist and a schedule.

______DATA PROCESSING SYSTEM PREINSTALLATION SCHEDULE

	DELIVERY DATE	DATE PREINSTALLATION SCHEDULE ESTABLISHED	SYSTEM NO.

	EST. LEAD TIME FOR COMPLETION PRIOR TO DELIVERY (NO. OF MO.)	STARTING DATES		COMPLETION DATES	
		ESTIMATED	ACTUAL	TARGET	ACTUAL
1. ESTABLISHMENT OF ORGANIZATION INCLUDES: A. APPOINT SENIOR IN CHARGE B. SELECT PROGRAMMERS					
2. INITIAL EDUCATIONAL PROGRAM INCLUDING: A. CLASSROOM B. ON-THE-JOB					
3. GENERAL SYSTEMS DESIGN IN PLANNING FOR THIS PHASE CONSIDERATION MUST BE GIVEN TO MANY REQUIREMENTS INCLUDING THE PERTINENT ITEMS INDICATED BELOW. A. ESTABLISHMENT OF PREINSTALLATION SCHEDULE OF EVENTS. (BAR CHARTS) B. APPLICATION DEFINITION BASED PRINCIPALLY ON THE FOLLOWING ITEMS: 1. REVIEW OF SOURCE DOCUMENTS 2. ANALYSIS OF FILE REQUIREMENTS 3. DETERMINATION OF REPORT REQUIREMENTS 4. ESTABLISHMENT OF DUE-IN AND DUE-OUT SCHEDULES 5. DEFINITION OF PROCEDURES WITH REGARD TO WORK FLOW 6. DEFINITION OF ORGANIZATIONAL CHANGES REQUIRED 7. DETERMINATION OF REQUIREMENTS FOR OPERATING PERSONNEL C. GENERAL FLOW-CHARTS D. BLOCK DIAGRAMS E. ALL BASIC CHANGES TO EXISTING SYSTEM DETERMINED AND AGREED TO AND A PLAN IN OPERATION TO EFFECT THEM					
4. REVIEW OF PHYSICAL INSTALLATION PLANS THIS MUST BE ACCOMPLISHED IN A MEETING WITH THE IBM SALES ENGINEERING REPRESENTATIVE, AND MUST CONSIDER THE FOLLOWING MAJOR ITEMS: A. SPACE B. POWER C. AIR CONDITIONING D. ROOM CONSTRUCTION E. CABLE REQUIREMENTS					
5. DETAILED SYSTEM DESIGN IN ESTABLISHING THE SCHEDULE FOR THIS ITEM CONSIDERATION SHOULD BE GIVEN TO THE FOLLOWING PERTINENT SUBJECTS: A. DETAILED FLOW CHARTS B. DETAILED BLOCK DIAGRAM OF MAJOR APPLICATION C. CODING BEGUN D. DETERMINATION OF DETAILED EQUIPMENT SPECIFICATIONS E. REVIEW OF SAVINGS AND COST ANALYSIS F. REVIEW OF DETAILED PREINSTALLATION SCHEDULE OF EVENTS (CODING TESTING ROOM CONSTRUCTION, ETC.)					
6. FIRST TEST SESSION COMPLETED					
7. ESTABLISHMENT OF CONVERSION PROCEDURES CONSIDERATION TO BE GIVEN TO: A. TIME SCHEDULE B. EQUIPMENT REQUIREMENTS C. PERSONNEL REQUIREMENTS D. PROCEDURES AND CONTROLS					
8. ESTABLISHMENT OF FIRM DELIVERY DATE METHOD OF DELIVERY, SPECIAL HANDLING REQUIREMENTS					
9. MACHINE ROOM LAYOUT AND CABLE ORDER APPROVED					
10. SELECTION AND TRAINING OF OPERATING PERSONNEL A. CONSOLE OPERATORS B. TAPE HANDLERS AND EQUIPMENT OPERATORS C. LIBRARIAN D. OTHERS					
11. CONVERSION AND MAJOR APPLICATION PROGRAMS TESTED AND READY FOR VOLUME OR PARALLEL PILOT RUNS					

Figure 5-2.—More detailed preinstallation schedule. 73.51X

GENERAL INSTALLATION SCHEDULE for the ________Data Processing System

To Meet the Installation Date of ________ 19____

Categories and items to be completed by end of month indicated — Year / Month

SELECTION OF PERSONNEL

Senior in charge
Systems Analysts
Programmers
Operators
Tape Librarian
Clerical Personnel

EDUCATION AND TRAINING

Programmer Training (School)
System Analyst (School)
Operator (School)
Programmer (On-job training)
System Analyst (On-job training)
Operator (On-job & test session training)
Tape Librarian (On-job & test session)
Auxiliary Operator (School & test sessions)
Auxiliary Department Personnel (Trained on premises)
Customer Employee Orientation

PUNCHED CARD MACHINE PERSONNEL CHANGES AND TRAINING

Card Punch & Verifier Operators
Sorter, Interpreter, Collator
Accounting Machines
Calculating Punches

EQUIPMENT AND SUPPLIES

Confirm all Data Processing System Specifications Punched Card, DP System & Auxiliary
Punched Card Machines Ordered
Forms Designed and Ordered
Cards Designed and Ordered
Magnetic Tape Ordered
Storage Files Ordered for Control Panels, Tapes and Forms
Control Panels Ordered
Desks, Work Tables and Chairs Ordered
Communications Equipment Ordered

CLERICAL

Procedures Written and Approved
Work Schedules Prepared
Workload Computed
Clerical Personnel Training

PHYSICAL INSTALLATION

Survey of Room Requirements
Selection of Site
Planning of Room Layout and Construction
Plans Reviewed with IBM
Moving Facilities Checked
Power Equipment Ordered
Air Conditioning Equipment Ordered
Construction Completed
Electric Power Balancing Completed
Air Conditioning Tested
DP System Cables Installed
DP System Moved into Room
IBM Customer Engineering Tests
Balancing of Air Conditioning
DP System Available for Use

78.52X

Figure 5-3.—General installation schedule.

DATA PROCESSING PLANNING REPORT

Activity — Site Preparation and Construction

Date of Installation ______________

	MONTHS BEFORE INSTALLATION																	
	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
	June	Jul.	Aug.	Sept	Oct	Nov.	Dec.	Jan	Feb.	Mar.	Apr.	May	June	Jul.	Aug.	Sept.	Oct.	Nov.
Selection of Site.	X																	
% of Planning Completed	50	60	65	75														
Room Layout Completed					X													
Site Review by Manufacturer. . .					X													
Manufacturer Review of Layout .					X													
Invitation to Bid.												X						
Contract Awarded.												X						
Air Conditioning Ordered													X					
Transformer Ordered													X					
Contract Completion Date.																	X	
Construction Started																		
% of Construction Completed. . .																		
Cables Ordered													X					
Tape Order Submitted													X					
Tape Storage Equipment Ordered																		
Furniture, Files, Ordered.																		

78.53X

Figure 5-4.—Data Processing planning report.

This record is in more detail than any discussed thus far. All activities necessary in connection with writing of each program are completely broken down. The schedule (fig. 5-10) illustrates and assures that every detail of the program is taken care of from its origination to its operation.

The mandays involved for each section of a job (documentation, desk checking, etc.) are estimated by the ADP manager, with the aid of the company representative. These estimates serve as an aid to determining whether there will be enough time to meet the installation date. These estimates also serve as a basis against which actual progress can be measured.

There are certain areas that should be considered when determining manpower availability. These are:

- Schooling
- Leave
- Military duties
- Holidays
- Test sessions
- Business meetings

In addition to these considerations thought must be given to:

- Establishing priority
- Scheduling jobs
- Program progress
- Program review

Establishing Priority

Job priorities are important toward meeting the installation date. For example, if there is a

DATA PROCESSING PLANNING REPORT

Activity — Education
All figures are to-date totals of the number of people trained

Date of Installation ____________________

	MONTHS BEFORE INSTALLATION																	
	18 Jun	17 Jul	16 Aug	15 Sep	14 Oct	13 Nov	12 Dec	11 Jan	10 Feb	9 Mar	8 Apr	7 May	6 Jun	5 Jul	4 Aug	3 Sep	2 Oct	1 Nov
Executive School	—	—	1	2	2	3	3	5	5	9	9	15	17	25	35	35	40	40
Systems Analysts	4	4	4	6	6	6	6	8	8	8	8	8	8	8	8	8	8	8
Programmers	4	4	4	6	6	8	8	8	10	10	10	10	10	12	14	16	16	16
Console Operators	—	—	—	—	—	—	—	—	—	—	1	1	2	2	3	3	4	4
Other	—	—	—	—	—	2	2	4	4	4	4	4	6	6	6	8	8	8
Employee Orient.	20	20	25	25	25	25	25	25	30	30	32	32	34	36	38	40	42	44
DP Methods	—	—	—	—	—	—	—	—	1	1	1	1	1	1	2	2	2	2
DP Engring. Execs.	—	—	—	—	—	—	—	—	4	4	4	8	8	16	16	16	16	16
Executive Seminar	—	—	1	12	12	12	12	25	25	25	40	40	55	60	60	75	75	75
Management Seminar	—	—	—	—	4	4	4	4	10	10	18	18	25	25	25	25	25	25

78.54X

Figure 5-5.—Data Processing planning report.

job that is run weekly and one that is run quarterly, the weekly job should have priority. The installation is dependent on the weekly job being finished; whereas, the quarterly job can be completed after installation. Therefore, priorities should be assigned as follows: daily, weekly, semimonthly, monthly, quarterly, and annually.

Scheduling Jobs

Once the job priorities have been assigned, each section of the job can be scheduled. These sections normally include:

- Document—both planned and current
- Define—run definition
- Code—coding
- Test—desk checking, test data preparation, and test and revision.
- Machine setup manual
- Parallel run
- Conversion.

Program Progress

Program progress as presented on the Bar Chart is on a monthly basis. Each phase of the program can be color coded to indicate the progress for the planned and actual time required for each section of the program. A more detailed version of this should be to assign codes to represent each section of the program (documentation, testing, etc.). Notice that in lieu of months illustrated on the Bar Chart, figure 5-11 is broken down into mandays. Here we have the estimated mandays, as well as the actual mandays required to complete each section of the program. As a day is spent on a particular section of the job the code for that section is posted on the control form on the actual-time-spent line.

Let's assume that we are doing an update program. Documentation (code 1) is estimated to take seven mandays, but we can see by

Personnel Assigned				Number of Programs By Language			% of Progress				Number Completed	Site Planning Complete	First Sched. Test Session	Test Time Used
D. P. Manager	Trained Programmers	Full Time Programmer	Part Time Programmer	RPG	Other	Total	Documented	Defined	Coded	Tested				

	Conversion Procedures Planned	Final Determination of Equipment Requirements and Delivery Date			Action Notes									
			Date of Order	Orig. Sched. Del.	Organ.	Personnel	Document	Prob Def	Program	Site	Test Time	Conv. Proc.	Accept	
Changes to Progress-to-Date														
Progress-to-Date														

78.55X

Figure 5-6.—Preinstallation schedule report.

comparison that only five actual mandays were used. We can see from this comparison that as programming continues, planned dates will sometimes be unrealistic and the estimates will have to be revised. A new form should be prepared at this point to reflect the new expected completion date.

Progress Review

The ADP manager should meet with top management for 1 to 3 hours each month to discuss the performance for the period just ended and develop plans for the next. If the schedule shows that efforts are behind schedule, steps must be taken to speed them up.

PROCEDURES AND DOCUMENTATION

Proper procedures and documentation are extremely important to the operation of an ADP facility. The installation of an ADP system will cause changes in the operations of both the departments supplying data to the system and those working with the system's reports and results. The establishment, clarification, and documentation of these changes are functions that must be performed. Programming and documentation techniques, standard program routines, and work procedures must be established as data processing policies or standards.

Procedures are known as functions whereby original source data are translated into accounting and management reports. A job can be

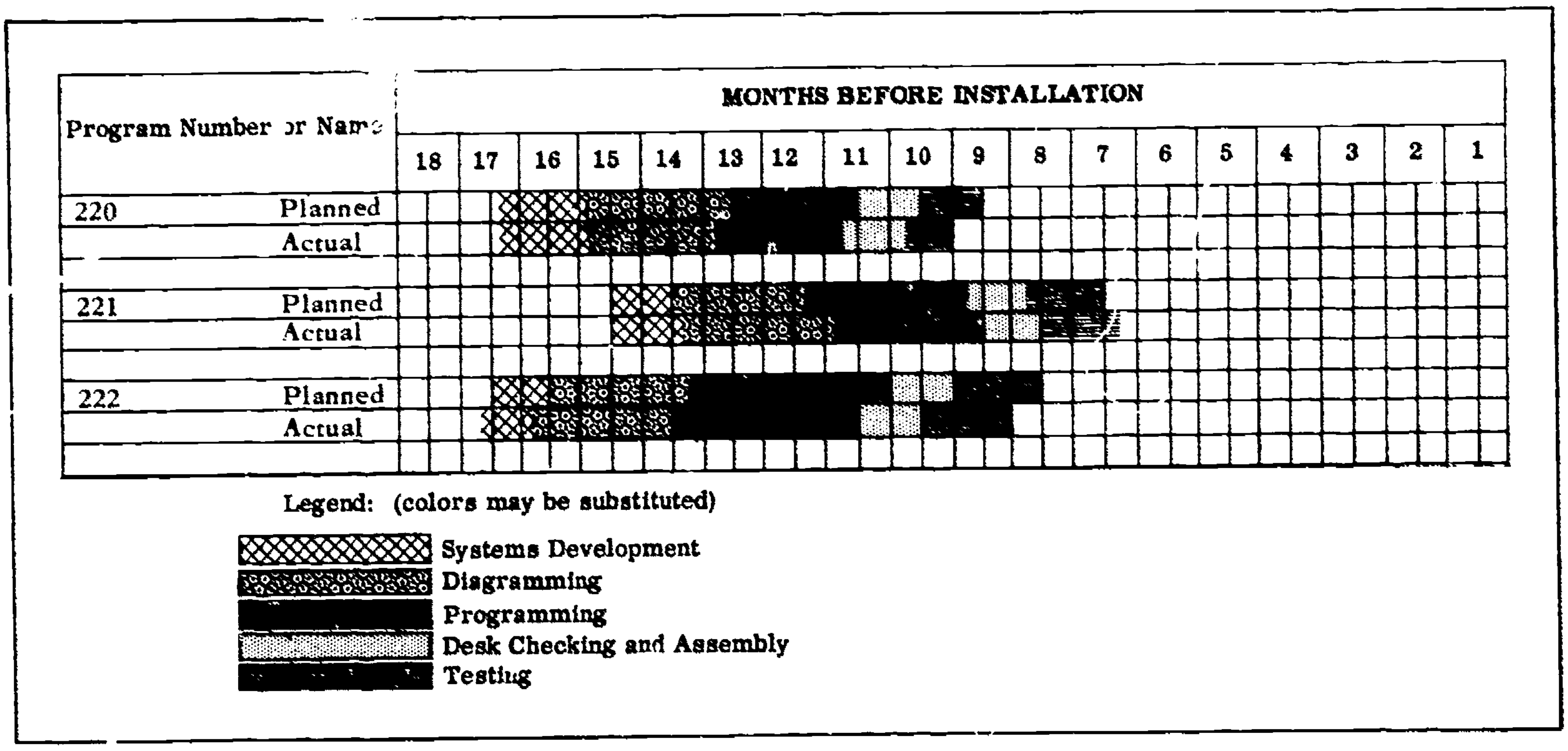


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Figure 5-7.—Application development bar chart.

PROGRAMMING SECTION

WEEKLY RECORD OF PROGRAM PROGRESS

PROJECT *Material Control* WEEK ENDING *April 30*

RUN NO. *201* PROGRAMMER *J. Doe*

TITLE *Transaction Edit*

ITEMS	DAYS SPENT THIS WEEK	EST. OF REMAINING DAYS NEEDED FOR COMPLETION	ESTIMATED % COMPLETE
1. PROBLEM DEFINITION	—	—	100 %
2. GENERAL BLOCK DIAGRAM	—	—	100 %
3. DETAILED BLOCK DIAGRAM	—	—	100 %
4. CODING	3	3	60
5. DESK CHECKING	—	2	30
6. DATA PREPARATION	1/2	1	50
7. TEST AND REVISION	—	7	—
8. RUN MANUAL	1 1/2	4	30
TOTALS			

REMARKS:

78.57X

Figure 5-8.—Weekly record of program progress chart.

RECORD OF PROGRESS CHART

REVISED: ______

1. MATERIAL CONTROL			1 Problem Definition		2 General Block Diagram		3 Detailed Block Diagram		4 Coding		5 Desk Checking		6 Prepare Test Data		7 Machine Test		8 Run Book		Date Started	Days to Date	% Comp.	Est. Total Days	Target Calendar Date
Prog. #	TITLE	Name of Programmer	% Comp.	Forecast/Actual																			
201	TE	Doe	100	8/8	100	3/3	100	10/10	63	5/8	33	1/3	50	1/2	0	0/7	33	2/6	6/20	30	67	41	9/10
202	SORT-SUM.	Lewis	100	5/5	100	4/4		4/4		3/3		1/1		½/½		0/2		1/2	4/8	16½	85	19½	8/15
203	FILE MAINT.	Doe	100	15/15		4/4		10/15		0/7		0/2		0/2		0/5		0/4	5/21	29	54	54	8/30
204	STATUS	Lewis	100	15/15		4/4		3/12		0/6		0/2		0/1		0/5		1/4	6/4	23	44	49	8/30
205	ACTION	Jones	100	7/7		0/3		0/6		0/3		0/1		0/1		0/3		½/2	7/1	7	27	26	8/30
206	FIN-[illegible]	Neil	100	10/10		5/5		2/10		0/5		0/2		0/2		0/4		1/2	7/1	18	45	40	9/10

78.58X

Figure 5-9.—Record of progress chart.

accomplished in many ways. In selecting or designing a procedure the man in charge must keep in mind that the required results must be obtained and that they must be accurate. Secondarily, but also very important, the job must be accomplished in the most efficient and economical manner possible.

The area of documentation, as used in conjunction with ADP, refers to recorded data concerning system development, programming and testing. It is a history—a diary—of the process involved in getting an application operational on a computer.

The objectives of procedure documentation are to gather all details concerning current jobs, and to record all details in a logical order so that references can be made to them as jobs are being established, defined, and readied for the proposed system.

The proposed computer systems design must be documented with a variety of flowcharts, diagrams, and instructions. Documentation is essential during change-over to provide for effective conversion of current systems. The ADP system should be documented with the following:

- System flowcharts
- Program flowcharts
- Source document layouts
- Output layouts
- Record estimates for each run
- Schedules
- Procedure manuals
- Job descriptions and duties
- Organization charts

The possibility of having the same people around to make changes several months or years later simply does not exist in the Navy.

A generally accepted rule is to document every application so completely that someone else can pick it up a year later and figure it out with a minimum amount of time and effort. Unfortunately, this is NOT generally followed because of the human disinclination to jot down things that seem obvious at the time. Also, there is normally a great deal of pressure during the period when documentation takes place. Programs must be written, tested, debugged and made operational—this is the immediate necessity and has to be done.

As pressure mounts and delivery date of an ADP system approaches, programmers tend to skimp on documentation in order to meet the deadline. The problem of making changes seems remote in contrast to the immediate problems of installation and implementation. Consequently, documentation suffers, and the whole operation is handicapped over the longrun in order to accomplish a shortrun objective.

Application ______________________ Operational Date ____________
Program ______________________
Items Completed by End of Month Indicated

Year
Month

PROBLEM DEFINITION

1. Written
2. Reviewed and Revised
3. Approved by Management

PROCEDURES

1. Application Flow Charted
2. Record Layouts Finalized
3. General Block Diagram Completed
4. Detail Block Diagram Completed
5. Coding Method Determined
6. Storage Assigned for Utility Routines
7. Checkpoint and Restart Procedures Written
8. Tape Control Procedures Written
9. Internal Controls Determined and Written
10. Program Written (Includes 7, 8 and 9 above)
11. Test Case Material Prepared (with correct results)
12. Program Proofread and Revised (Desk Checking)
13. Program Cards Punched and Verified
14. Program Listed in Required Sequence
15. Program Halts Listed
16. Block Diagrams labeled with corresponding instructions
17. All Control Panels Wired (and tested when possible)
18. Program Testing
19. Program Revision and Preparation for Next Test
20. Run Book (Material Prepared)
21. DP System Operating Schedules Written
22. Final Testing and Approval of Program
23. Conversion Operation Completed
24. Parallel Operation Completed
25. Program Operational

PUNCHED CARD AND AUXILIARY MACHINE PROCEDURES

1. Procedures Written and Approved
2. Test Decks Prepared
3. Control Panels Wired and Tested
4. Machine Schedules Prepared
5. Machine Loads Computed
6. Card Files Edited
7. Card Files Corrected and Ready for System

CLERICAL PROCEDURES

1. Procedures Written and Approved
2. Personnel Schedules Prepared
3. Workloads Computed
4. Clerical Personnel Trained

TRAINING

1. Operators Trained on this Program
2. Auxiliary Personnel Trained on this Program

78.59X

Figure 5-10.—Program development schedule.

SYSTEM 1440 BY CBM

PAGE 1 of 1 DATE oct. 2, 19-

PROGRAM NAME	NO.	PROGRAMMER	MAN DAYS																									
Payroll	220	Smith	SCHEDULE	1	1	1	1	1	1	1	2	2	2	2	3	3	3	4	4	4	4	4	4	4	4	7	7	7
			ACTUAL	1	1	1	1	1	2	2	2	2	2															
Inv.	221	Jones	SCHEDULE	1	1	1	1	1	2	2	2	3	3	3	4	4	4	4	4	4	5	5	5	6	6	7	7	
			ACTUAL	1	1	1	1	1	1	2	2	2	3	3	3	3												
			SCHEDULE																									
			ACTUAL																									
			SCHEDULE																									
			ACTUAL																									
			SCHEDULE																									
			ACTUAL																									

78.60X

Figure 5-11.—Schedule control form.

It is by means of procedures that the ADP manager will be able to meet the large demands placed on the installation. Getting the work out in time and in an acceptable form is possible through the help of procedures as the duties and operations of each job are clearly defined. They make it possible to render the type of ADP services desired.

PROGRAM EVALUATION AND REVIEW TECHNIQUE

Program Evaluation and Review Technique (PERT) is but one of the operations research tools developed to aid management in planning and decision-making. This tool, based upon the network theory, is a powerful but simple technique which is particularly useful in analyzing, planning, and scheduling large complex projects. It also provides a means of determining which jobs or activities comprising a project are critical in their effect on the total project time and how best to schedule all jobs in a project to meet a target date at minimum cost.

PERT is specific and based primarily on goals. Figure 5-12 is an illustration of a PERT network. Each event from A through N is a goal. Event A is the goal to begin the project, event N is the goal of the project's completion, and all the events in between are intermediate goals which must be met along the road. The line connecting these events or goals represents the work or the activities necessary to reach the next goal.

PERT can be a valuable tool for the systems analyst as well as the manager. Both are vitally concerned with planning, and whenever any plan is of sufficient complexity to justify putting it on paper, PERT will provide a better way to do it. Among the many projects which would lend themselves to the application of PERT are:

- Installing and debugging a computer system
- Scheduling ship construction and repair
- Constructing a building or new highway
- Planning and launching a new product
- Manufacturing and assembly of large generators

There is a lot to know about PERT and you may not find all the information you need on the subject in this training course. We will however, examine the principles and fundamentals of PERT, define the terms associated with it, and illustrate its use by showing how it might be applied to the installation of an ADP system.

BASIC CONCEPT OF PERT

PERT embraces a group of management concepts, each of which can be used effectively by itself; but when grouped together into an integrated system, they ensure the optimum use

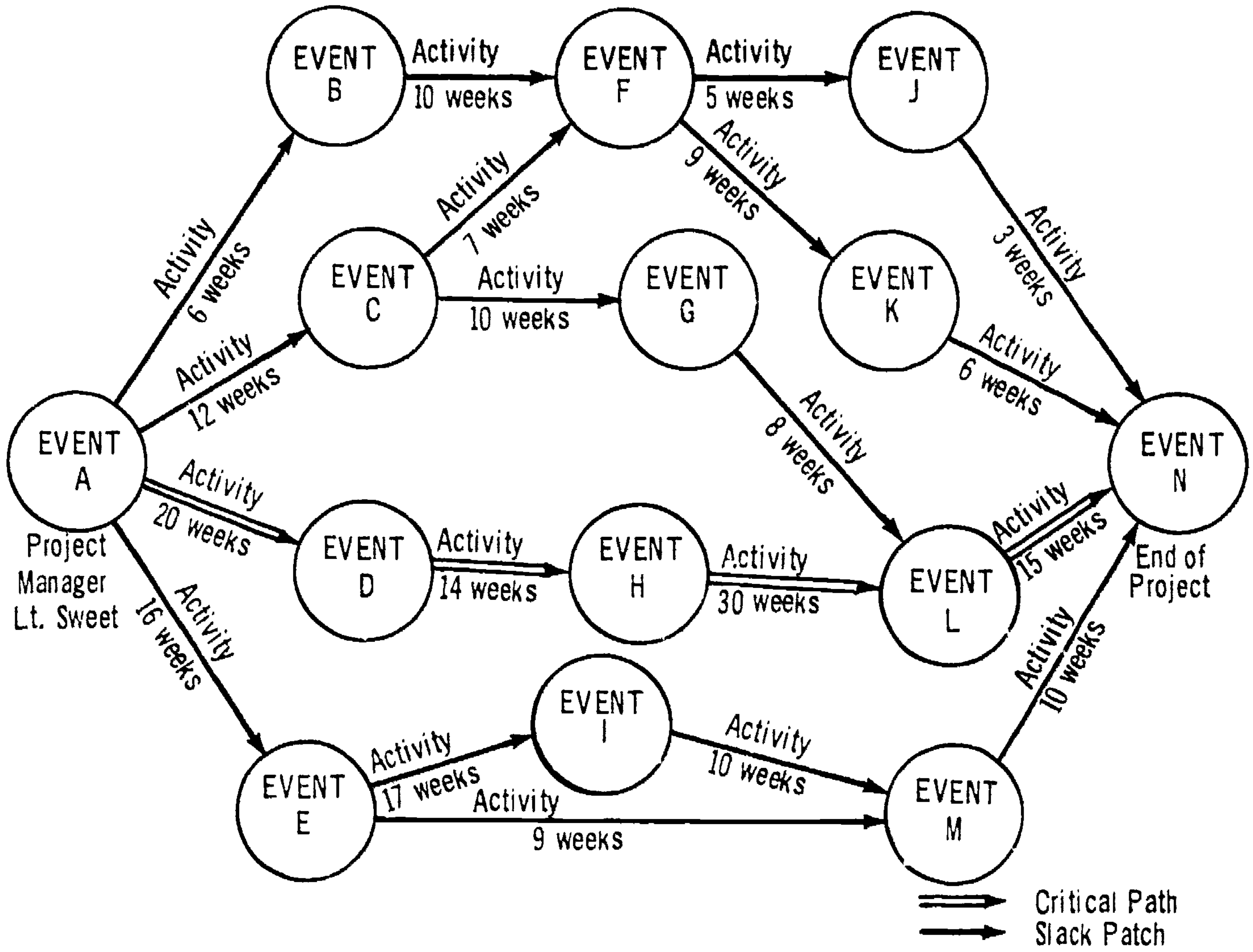

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Figure 5-12.—PERT network.

of time and resources available to accomplish a known goal. Among these concepts are:

- The use of a network to represent plans
- The prediction of time needed to complete each phase of the project
- The recognizing and measuring of uncertainty
- The continual revision of plans and operations to meet unpredictable situations and environment

By combining these time-tested management procedures in one overall approach, PERT provides a means of defining, interrelating, and integrating what must be done to accomplish project objectives on time. PERT, then, is a detailed and interrelated master plan that has sufficient built-in flexibility to serve as a stable guide for a complex project through its many steps to completion.

EVOLUTION OF PERT

Many techniques, procedures, and systems have been developed to aid the manager in the fulfillment of his responsibilities. Traditionally, these aids have been most effective in a manufacturing or continuous type of production application. Among these techniques are the flow process chart, the Gantt chart, the milestone chart, and bar charts. These techniques are not by any means obsolete; in fact, each has a place for use in production applications. However, management found that these existing techniques did not completely meet their needs in the "special project" area. Therefore, using these previously developed techniques as a point of departure, managers of special projects selected the appropriate procedures from these formerly successful techniques, added their own unique methods, and devised this relatively new and integrated means of planning, called PERT. PERT, then, was not developed by a revolutionary process; instead, it could be better described as a product of evolution.

The actual development of PERT is attributed to the Special Projects Office, Navy Department. An interesting result of this system was the method of planning the construction and delivery of new missile and missile-firing submarines which were completed years ahead of the originally scheduled time. An outgrowth of PERT is the technique called CRITICAL PATH METHOD (CPM) which was developed in private industry to meet similar management needs.

Since its initial success on the Polaris program, the use of PERT on other Government projects has resulted in the saving of time and money. For this reason, PERT has been receiving increased emphasis in the Department of Defense. As a result, the use of PERT has spread rapidly throughout the United States defense and space industry.

PERT PLANNING

Before beginning to use the PERT network to plan in detail a major project, the manager or systems analyst should organize his thoughts concerning the project by defining his objectives and dividing his large project into its major work areas.

Development of Program Objectives

The manager's first job is to define the project. Before using PERT to aid in the planning of a complex project, a person must know exactly what he hopes to accomplish. Two specific procedures are of great help in defining the objectives of a project.

(1) The large, complex project must first be broken down into manageable subdivisions. When this is done, the manager must define the objective for each subdivision in sufficient detail to enable a person unfamiliar with the project to know specifically what must be accomplished before that section of the overall project is completed.

(2) In defining the objectives for each subdivision, the manager should begin with the ultimate objective of the entire project and work back toward the beginning of the project. This is called a top-down approach. By following this procedure the entire project is totally related to the final objective of the entire project, and the manager can easily recognize any area that does not in any way help achieve the ultimate goal. Furthermore, by developing from the end product, all parts of the program are totally integrated into the total program. In this way, we can see the interdependencies and interrelationships of all the program objectives.

At this point the manager must itemize the various tasks that need to be accomplished to meet the final objective. These tasks should be arranged in the order that they will occur and assigned to those individuals who will have primary responsibility for their completion. To do this the top manager uses a work breakdown structure in which he takes the final, intermediate, and initial objectives and converts them into work areas.

- In any integrated time resource management system, it is imperative that both resources and time are planned and controlled from a common framework or structure which defines the major areas of work effort and their interrelationships. Such a common framework provides a master plan whereby all aspects of the project may be managed. Using the top-down approach, the manager starts from the highest level of management which will use PERT as a vehicle for controlling the progress of the project, and progressively breaks down each component part of the project into orderly subdivisions until the least significant subdivision becomes the smallest manageable unit for planning and control purposes. These smallest manageable units are called end item subdivisions. They represent the hardware, equipment, or facilities that are used, and the services that are to be performed. Each of these end items could be further subdivided into functional phases.
- The number of subdivisions of a project depends upon several factors:

(a) How large and how complex is the project? A small project will have a limited number of levels, and a large or complex project will have many levels.

(b) What is the degree of certainty in the work? As the degree of uncertainty increases, more levels will be required.

(c) How familiar are the people with the work to be performed? The less familiar the operating personnel are with the work to be done, the larger will be the number of levels required.

(d) How much time is available? The more time we have available, the more levels we can use.

(e) How many participating organizations are involved, and how complex are their structures?

(f) Who is responsible for each phase of the work?

- Sections of the work breakdown structure can vary in the number of levels into which they are divided. Certain areas such as major phases of work effort which represent significant expenditures of time and/or resources warrant the establishment of several levels. Other areas such as test operations will not necessarily warrant as many levels.
- For each level in the work breakdown structure, objectives and plans for meeting the objectives must be formulated.
- There are several advantages in developing a work breakdown structure. Among these are: It defines the tasks involved in a project through an exhaustive analysis of the entire project. It establishes a framework for planning and controlling the schedule and performance objectives for all levels of management. Finally, it establishes the basis for constructing the PERT network diagram and facilitates defining project tasks and activities.

NETWORK DIAGRAMMING

After the manager has completed his work breakdown structure to determine the basic administrative and physical task involved in the project, the actual construction of a PERT network is not difficult. This network is a visual presentation of the flow plan of the project objectives. Figure 5-13 illustrates the arrow elements of network diagramming.

Explanation of Terms

The following terms are unique to the concept of PERT. Before discussing the network diagram in detail, we must understand the meaning of these terms.

EVENT.—An event, or milestone is an identifiable point in time at which something is accomplished. There may be work and, therefore, time involved in bringing about this accomplishment. In the PERT network, an event is shown as a circle, square, or some other symbol. For our purpose, we use only the circle. Events are numbered from left to right through the diagram. Obviously, the event number at the head of an arrow must be larger than the event number at the tail.

ACTIVITY.—On the PERT network, shown in figure 5-12, you undoubtedly noticed the term "Activity." You also noted that an activity is represented on a PERT network by an arrow and that an activity separates one event from another. An activity is a clearly defined task to which a known quantity of manpower and other resources is applied. Each activity represents effort and resources applied over a period of time. An activity is always bounded by two events.

NETWORK.—Up to this point, the term "network" has been used many times, and you have seen two examples. But, let's examine this concept a little further. The network shows the interdependencies among the tasks or activities and illustrates the sequence in which they are planned. It shows for each step of the plan the work that must precede the other steps and the activities that may be carried on simultaneously or independently. Through the use of detail nets, which show the project plan in complete detail; summary nets, which depict the major events and activities of the plan; and subnets, which portray sections of the master plan, subordinate participants may clearly see what parts they must carry out and how their work relates with the work of others, and better understand their responsibility toward securing the goal. In this way the manager may design the level of detail to be consistent with the level of management, and higher levels of management can also be quickly informed of a proposal for their consideration or approval.

Developing the Network

One question which should always be asked when constructing a PERT network is, "Does this network show the truth—the real way the project will be accomplished?" The way it should be done is a problem that should be resolved long before the actual construction of the PERT network. In depicting the truth on the PERT network, the interrelationship and interdependency of events and activities must be accurately shown. To determine this interrelationship and interdependency of events and activities is the most difficult task of the PERT

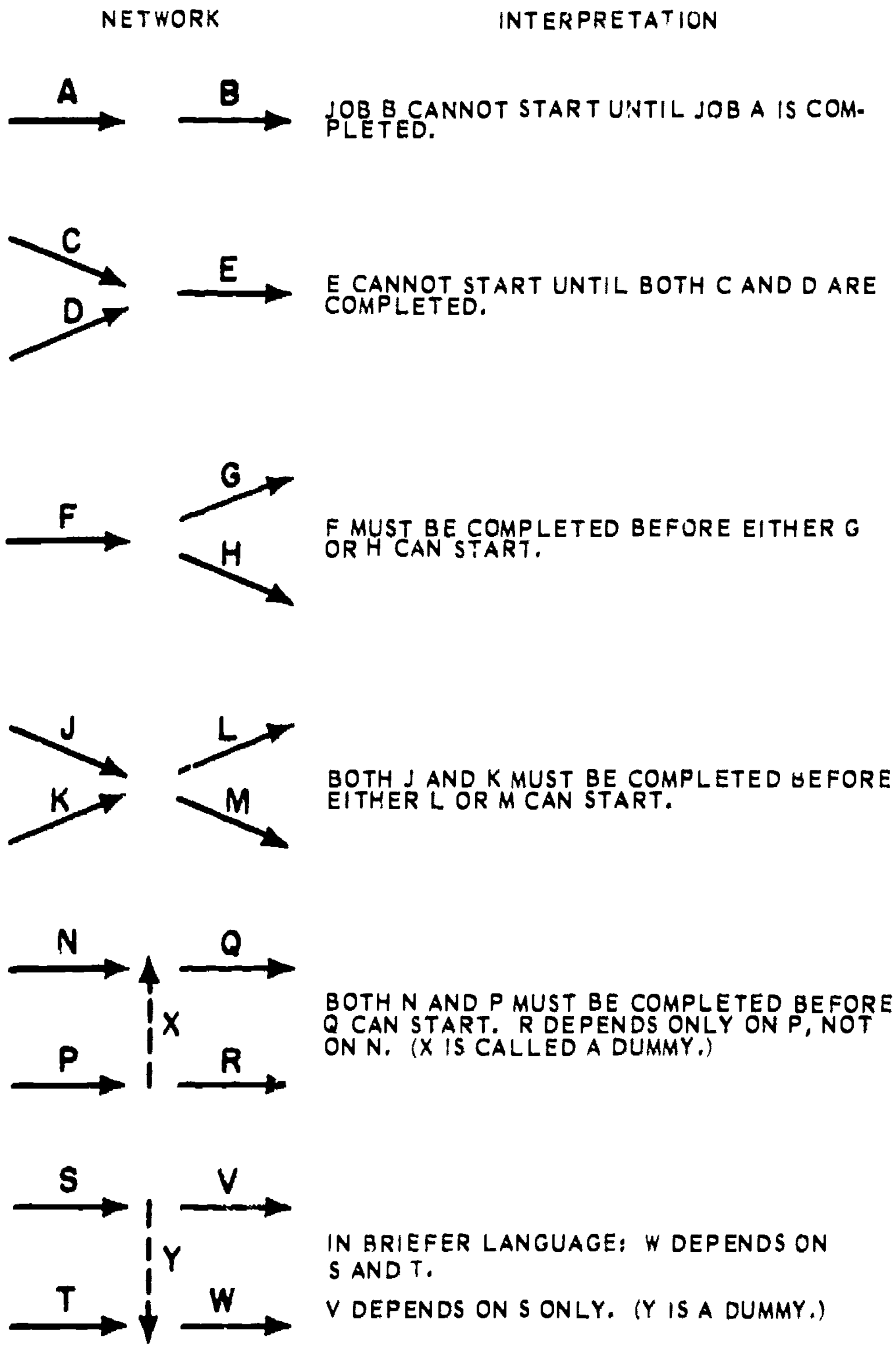

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Figure 5-13.—Elements of network diagramming.

analyst. Some managers who are experienced with this procedure believe that the best way to accurately construct the network is to start with the end event and work backwards. Others maintain that it is better to start at the beginning event. Whichever way the user finds easier is the best way for him to build his PERT network. In either case, the analyst must know how to correctly express activities and events if he is to design a workable network.

In developing a PERT network, the manager can simplify his task if he has established a set of rules to guide him. These rules will vary with the individual, the project, and the methods used. The following is one suggested set of rules or procedures for expressing the events within the PERT network:

- Define the beginning event with a title which describes the project. For example, note figure

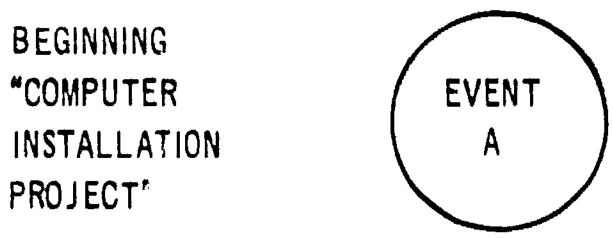

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Figure 5-14.—Beginning event.

5-14, which depicts the beginning of a network defining a computer installation project.

• Establish and define events that are significant to the beginning. For example, note figure 5-15. The "chain" or connection of these events should not be started until after all events significant to the beginning have been established and defined, a line is drawn between these events and "event A" as shown in figure 5-15 and to other events to which it is related. For example, the site selection affects the installation plans. Therefore, the interrelationship of the site selection event and the plan development is clear. Thus, a line would be drawn between event D and event C with the arrow pointing toward event C. The direction of the arrow is determined by which event must be completed first. In the preceding case, installation plans are usually developed after the site selection has been made.

• Establish and define all significant events involved in completing events B, C, and D (fig. 5-16). Again, no attempt should be made to connect these events or make the "chain" until it is certain that all events involved in completing events B, C, and D have been established, defined, and recorded on the PERT network (note figure 5-15). Then, the chain or connecting lines establishing the relationship of events can be drawn.

• To complete the network construction, continue in a similar manner with all other events. By working forward, a level at a time, all significant events involved in the project are established and defined. After completing the events portion of the network, a thorough study should be made of it. All significant events except the beginning and ending ones should have, at least, one connecting event on each end. When a significant event does not have a connecting event on each end, it indicates that an event has been omitted. The omitted event must be defined and a determination must be made as to whether or not it is covered by the scope of the project. If it is covered by the scope of the project, it must be included in the network; if not, it may be omitted.

• There are three basic concepts involved in expressing activities on a PERT network. First, the correct method must be used in expressing those activities in which one activity precedes another. Second, the correct method must be used to express those activities which are being done at the same time. Third, each activity must be shown as having a unique pair of events.

(a) When one activity precedes another, the two activities are separated by an event as shown in figure 5-17.

(b) When more than one activity is being done at the same time in order to approach a particular event, all activities are expressed on a PERT network, as shown in figure 5-18.

(c) Each activity expressed on a PERT network must be described or bounded by a unique pair of events so that managers are able to explicitly identify each activity. But

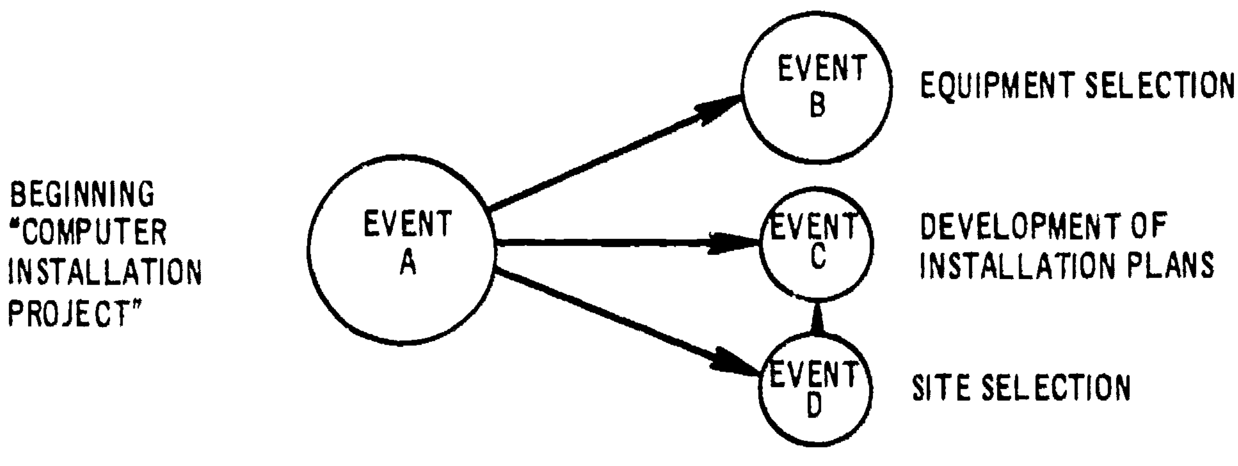

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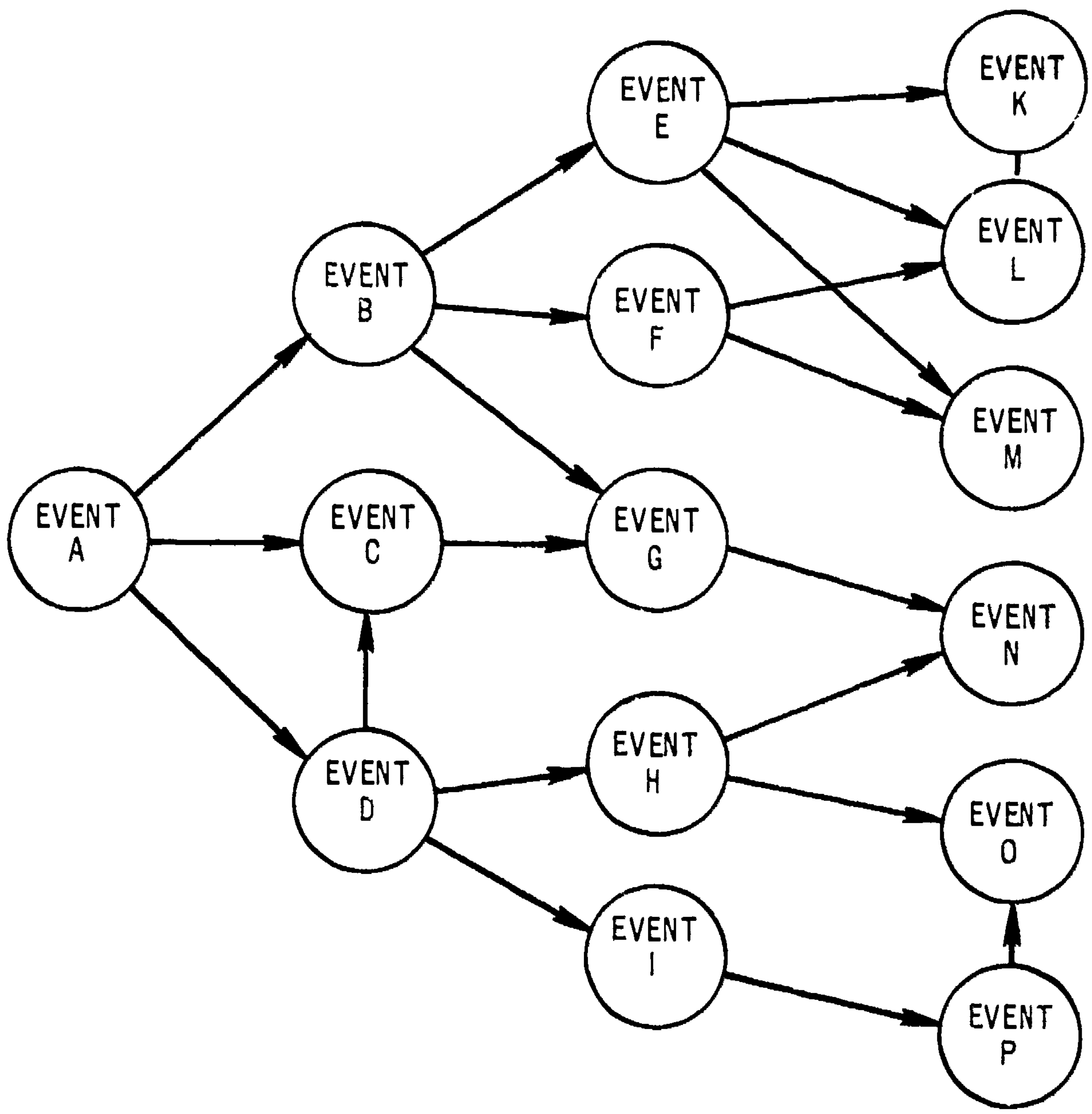
Figure 5-15.—Beginning of a network.



78.126

Figure 5-16.—Continuation of a network.

78.127

Figure 5-17.—Two activities separated by an event.

two activities cannot be bounded by the same pair of events.

For example, in figure 5-19, two activities emerge from a previous event. One event is entitled "Auxiliary machine procedures;" the other, "clerical procedures." As shown in figure 5-19, these activities are bounded by the same pair of events. Since two activities cannot be bounded by the same pair of events, the activities are shown incorrectly in figure 5-19.

Figure 5-20 illustrates how these activities should be shown. The activities "auxiliary machine procedures" and "clerical procedures" must be completed prior to the beginning of the next activity. Obviously, both activities must be completed before the event "management approval" can be accomplished.

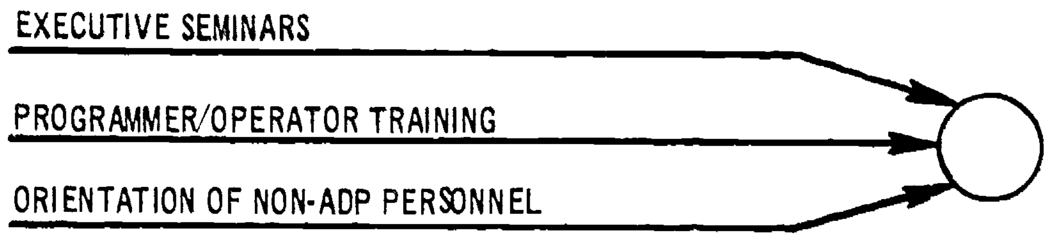


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Figure 5-18.—Expressing more than one activity being done at one time.

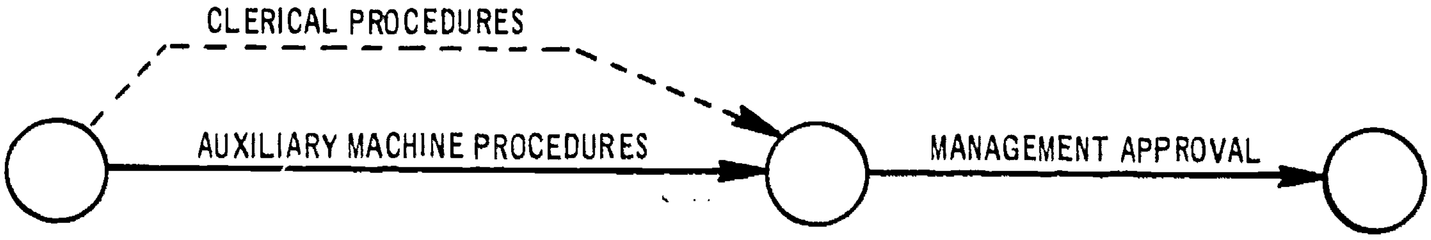

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Figure 5-19.—Incorrect representation of activities.

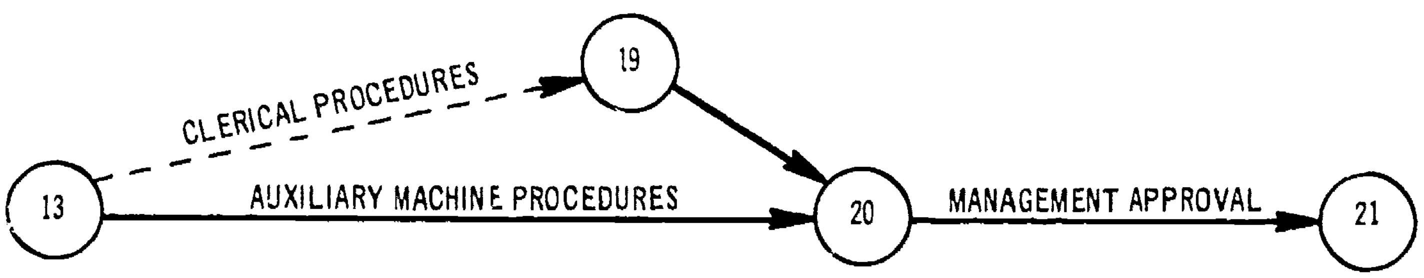

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Figure 5-20.—Correct representation of activities.

To depict this situation correctly on a PERT network, a DUMMY activity must be used. Dummy activities are used to comply with the principles of network construction which must have a unique pair of events. A dummy activity is represented by a dotted line similar to the one between events 18 and 19 in figure 5-20. It is used only to show relationships and dependencies between activities and to add clarity to the network diagram.

• When completed, the network diagram will show a unique identification for each activity, significant points needed for reporting purposes, all activities leading to the completion of an event, and all restrictive relationships between events.

• Once the PERT network is constructed, one can start to see the power of this technique. Managers can see how the status of a single event or activity could effect subsequent events and activities. Other advantages of the PERT diagram are as follows:

(a) It is an excellent vehicle for communication.

(b) It identifies interrelationships and interdependencies.

(c) It forces detailed planning.

(d) It provides a basis for making changes.

(e) It uncovers difficult areas.

(f) It relates the various parts to the whole.

DETERMINING EXPECTED TIME

One of the tasks of the PERT analyst is to obtain time estimates for completion of each activity shown on the network. This is necessary because PERT associates an elapsed time with an activity. Elapsed time is the amount of time that it takes from start to completion of an activity. In order to determine what this elapsed time is likely to be, it is necessary to estimate. This estimating procedure is one of the basic concepts of PERT and is designed to recognize the uncertainty in an activity and to arrive at more precision in planning figures.

Time Estimates

To determine the estimated elapsed time for each activity, the analyst must obtain three time estimates which are initially entered for each activity on the network. These estimates are obtained from the individuals who are responsible for performing the various activities in question or those with the greatest knowledge of the activity which is to be performed.

OPTIMISTIC TIME.—Optimistic time is the minimum time required to complete a given activity. This time estimate is based upon the expectation that everything involved in accomplishing the activity will go perfectly, or will be accomplished under the best possible conditions.

PESSIMISTIC TIME.—Obviously, pessimistic time is the opposite of optimistic time. This time estimate is based upon the expectation that everything involved in accomplishing the activity that could go wrong will go wrong. Thus, this time estimate is the maximum time in which this activity could be accomplished.

MOST LIKELY TIME.—This time estimate is defined as the time allowed for the completion of an activity based upon the past experience of the estimator. This allows for both good and bad circumstances to enter into the completion of an activity. It is the time that would occur if the activity were repeated many times under exactly the same conditions. This is the best "honest time" estimate that the estimator can make.

EXPECTED TIME.—Expected time is the time in which the agency responsible for completing the activity will have a 50 percent chance of completing it in that time or less. This is done by combining the three time estimates mathematically. One formula for finding the expected time, sometimes referred to as "mean time," is:

$$te = \frac{A + B + 4M}{6}$$

In this formula "te" means expected time, "A" is optimistic time, "B" is pessimistic time, and "M" is most likely time. Thus, the formula can be translated as follows:

$$\text{Expected time} = \frac{\text{optimistic time} + \text{pessimistic time} + \text{four times most likely time}}{\text{divided by six}}$$

For example, the optimistic time for a specific activity is 50 days. The pessimistic time for this activity is 100 days while the most likely time is estimated at 75 days. Using our formula we calculate expected time as follows:

$$te = \frac{50 + 100 + 300}{6}$$

$$te = \frac{450}{6}$$

$$te = 75$$

If we knew the probability function for completing the activity, we would use this in computing activity time rather than the formula just discussed. (Probability function is beyond the scope of this text.)

EARLIEST TIME, LATEST TIME, AND SLACK TIME

The critical path consists of the sequence of events and activities which ultimately determine the earliest possible time for completion of the project. In other words, the critical path is the longest time path through the network and will thus control the completion schedule of the entire project. In order to determine the critical path, we must have a completed network diagram which includes proper logic and all events and activities with their interrelationships. Furthermore, the expected time for each activity must be reordered on the network. Note on figure 5-21 (which has the specified activities deleted) the number "1" between events 0 and 1, the number "25" between events 1 and 10, and the number "10" between events 1 and 5. The cited numbers indicate the expected time required to complete the activities between the events indicated, and serve as the basis for computing earliest time, latest time, and slack time.

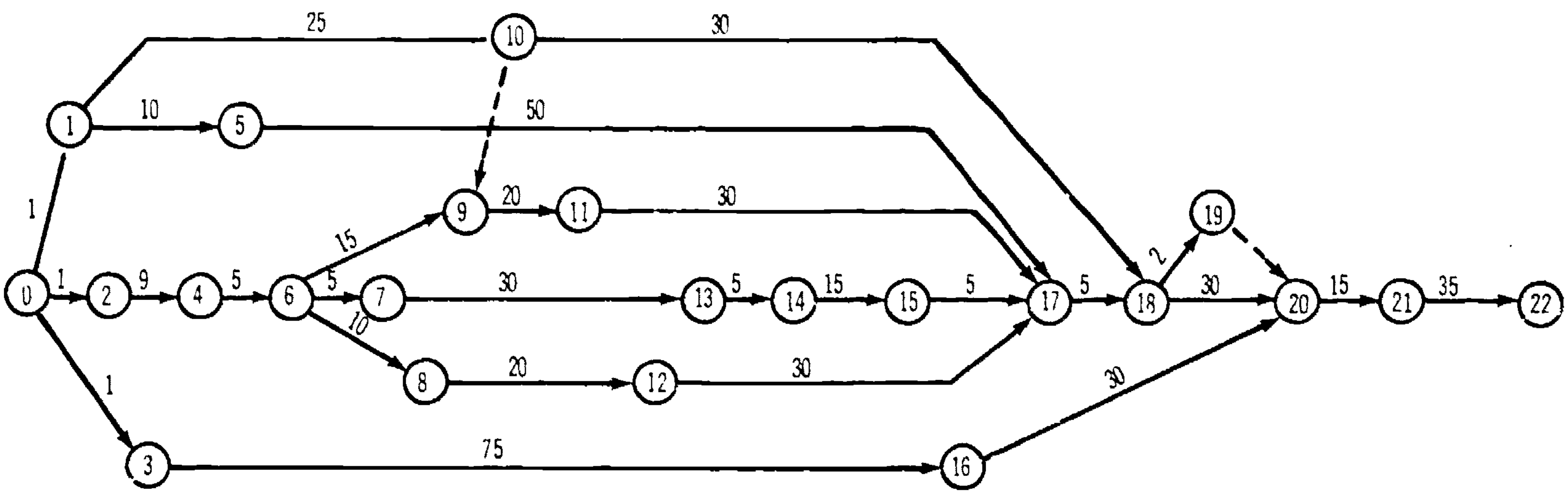

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Figure 5-21.—PERT network displaying activity times.

Earliest Time

The first step in the procedure used to determine the critical path is to determine the earliest possible time (called earliest time) for the completion of each event in its proper sequence along one or more paths. In calculating the earliest time for each event, start with the first event or the starting event of the PERT network and proceed from left to right across the network. From this starting point, note the determined expected time along each path to the next event. For the first event on each path, this involves merely noting the expected time for the intervening activity, in figure 5-21, the earliest time for events 1, 2, and 3 is "1." Determining the earliest time for the subsequent events along a path requires addition; one must add the expected time for each event to the earliest time (TE) for the preceding event. For example, in figure 5-22, event 6 has an earliest time (TE) of 15; this is determined by adding 5 for the expected time between events 4 and 6 to the TE determined for event 4 (10).

When two or more activities come together at a specific event, we call the event a merge point. To determine the earliest time at a merge point, all paths leading to that event must be considered and the one with the longest time value should be selected. For example, note event 9 of figure 5-22. Two activities come together at this merge point: one activity stems from event 10, is made up of the path connecting events 0, 1, 10, and 9, and has an earliest time count of 26: another activity stems from event 6, is made up of the path connecting events 0, 2, 4, 6, and 9, and has an earliest time count of 30. Obviously, the longest path in terms of time value would be the path stemming from event 6 with a time value of 30; this is the path used to determine the earliest time of event 9.

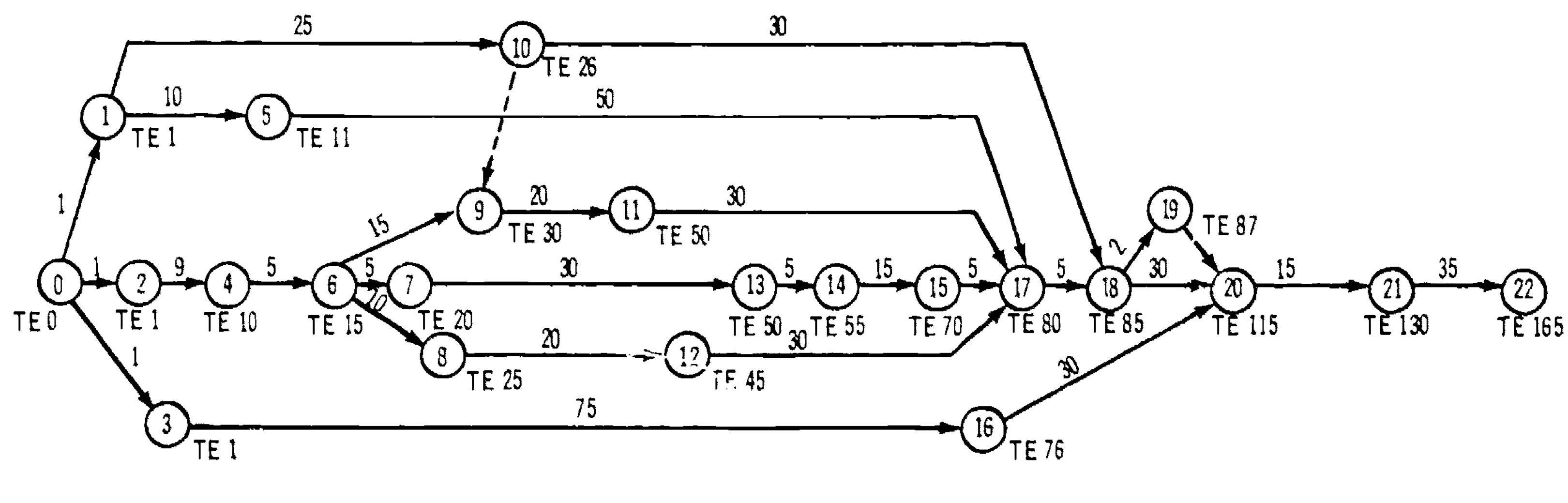

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Figure 5-22.—PERT network displaying earliest time (TE) for each event.

Latest Time

The next step of the procedure used to determine the critical path is to determine the latest possible time (called latest time) by which each event in the network must be completed to meet the established completion date. The procedure for counting the latest time is the reverse of the method for counting the earliest time since the calculating begins with the final event of the network and proceeds back across the network from right to left.

The first factor which must be determined in calculating latest time is the point in time when the final event must be completed. In other words, when must the entire project be finished? Because of emergency conditions, a project may need to be completed within 150 days. On the other hand, the project used as our example may be given 180 days for completion. In such instances, the 150 or 180 days that have been established for the completion of the project would also be the latest time (TL) for the final event of the project.

However, the latest time (TL) is usually the earliest completion time of the network. For example, we determined in figure 5-22 that the earliest time for the completion of event 22 is 165; hence, the most logical latest time (TL) for this network is 165. Therefore, for purposes of illustrations, we will use 165 as the established point in time for the completion of the project. Then 165 becomes the TL for event 22.

The second factor to be determined in computing the latest time for an event is the amount of time involved in completing the activities on the appropriate path between the final event and the event in question. To determine this, we must subtract the intervening activity time from the latest time established for each event in its proper sequence along a path of the network. For example, in figure 5-23, to determine the latest time for event 21, we merely subtract the activity time between event 21 and event 22 (35) from the established latest time of 165. Hence, the latest time for event 21 is 130.

The next event for which we must compute latest time (TL) is event 20. This is done by subtracting the intervening activity time between event 20 and event 21 from the TL for event 21 (130). Hence, the TL for event 20 is 115.

Since no activity time is involved in the dummy activity between 19 and 20, the TL for 19 is also 115.

Event 18 presents a new problem. When two or more activities stem from an event we call that event a burst point. Two activities stem from the burst point at event 18; these activities are the activity between 18 and 19 and the activity between 18 and 20. In such a case the latest time (TL) must be computed for both paths and the one with the lowest time value should be selected. In the case of event 18, the computation from the path leading from event 19 results in a TL of 113 (115 minus 2), whereas the computation for the path leading from event 20 gives a TL of 85 (115 minus 30). The lowest time value of the two TL's is that of 85; therefore, the TL of event 18 is 85.

By backtracking on each path, the latest time for each event is computed in order of occurrence, subtracting the intervening activity time between the event in question from the TL for the preceding event. The TL for event 17 is 80 (85 minus the intervening activity of 5). From

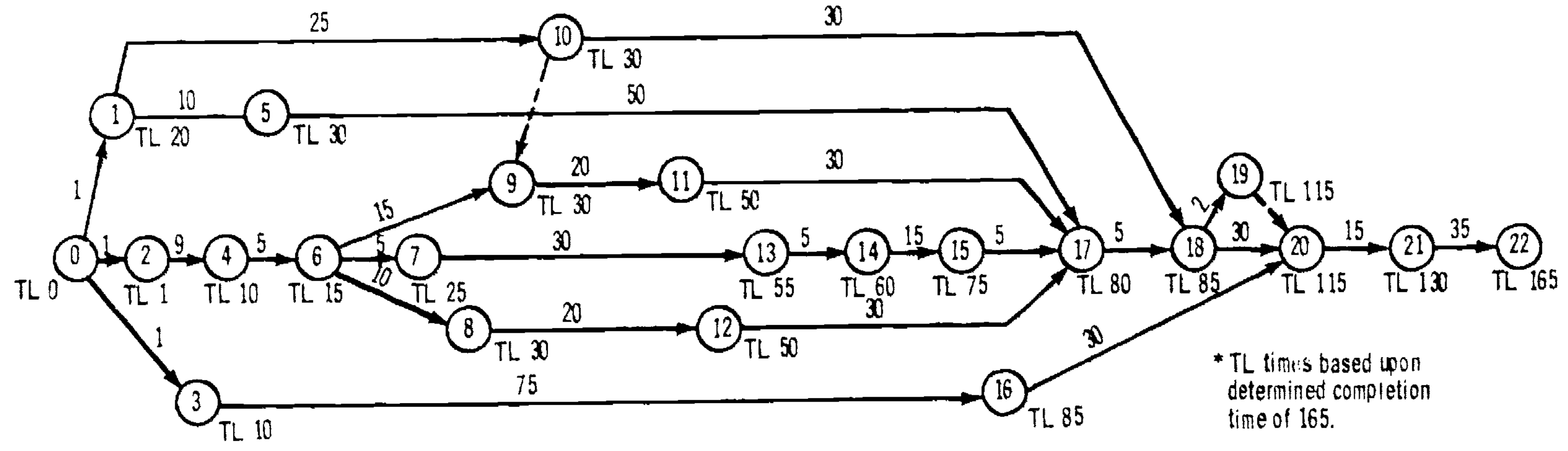

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Figure 5-23.—PERT network displaying latest time (TL) for each event.

this merge point at event 17, the TL for all events on each of the separate paths are calculated in the order of their occurrence.

Slack Time

The third step in the procedure for determining the critical path is to determine the slack time for each event on the network diagram. This is determined by simply subtracting the earliest time (TE) value from the latest time (TL) value for each event. For example, in figure 5-22 we determined that the earliest time (TE) for the completion of event 3 was 1, and in figure 5-23 we determined that the latest time (TL) for the completion of event 3 was 10; the slack time, therefore, for event 3 would be 9. It is possible to get a plus (+), a zero (0), or a minus (-) result. A plus result indicates excessive time. A zero indicates that there is just enough time. A minus condition shows that there is not enough time. The formula for computing slack time in any of these cases for a particular event is: TL - TE = t^1. (See figure 5-24.)

Those events which have a slack value of zero will usually be on the critical path. However, if the time for the entire project is reduced, events on the critical path will have minus slack value. In such cases, events with a slack value of zero could well be on a slack path. Likewise, if the time for the entire project is extended, all events will have a plus slack time.

DETERMINING THE CRITICAL PATH

Upon completing the time calculations for a PERT network, we are ready to determine the critical path. The critical path is made up of all the events with a minimum event slack time (t^1) on one specific path through the network. These events and their connecting activities represent the longest path between the beginning event and the final event. If the estimated time for any of the activities along the critical path is extended, the time for the entire project will be extended by a corresponding amount. Conversely, if the time for any event along the critical path is shortened, one of two things can happen. The critical path may remain the same and the time for the entire project shortened by a corresponding amount. A new critical path with the same or shortened completion time than the original completion time may be developed. Usually on a large network diagram, only 10 percent of the activities in the network are on the critical path.

From an analysis of the critical path, the manager can tell which activities and events must be completed on time to insure that the projected completion date of the project is met.

Furthermore, the determination of the critical path enables the manager to more effectively use his critical resources. All other paths through the network except the critical path are slack paths. These indicate to the manager where excess resources and/or time in the form

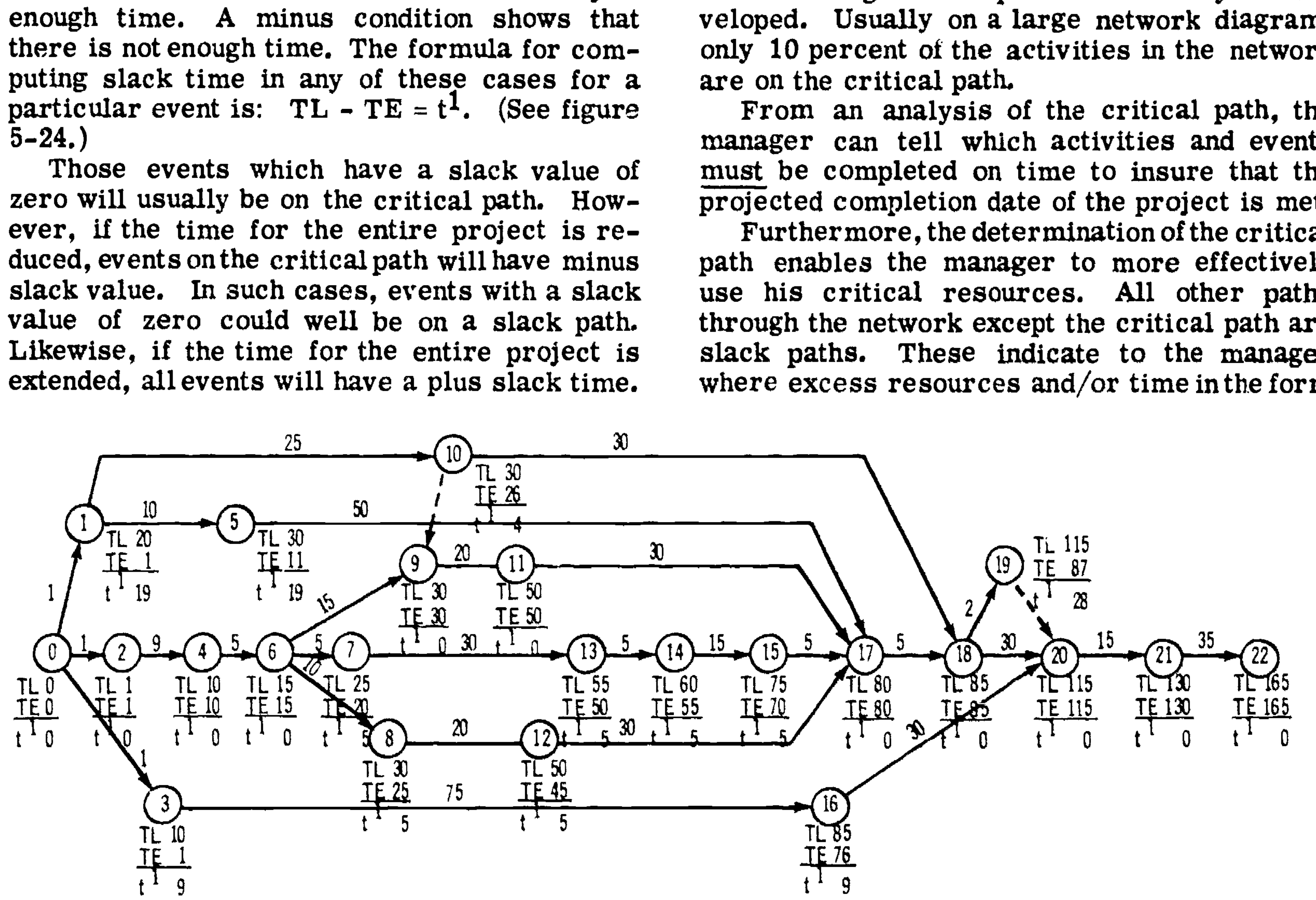

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Figure 5-24.—PERT network displaying computed slack time (t^1) for each event.

of "slack" exist. An analysis of these slack paths helps insure that the project is being executed in the most efficient manner. Slack paths may have resources which can possibly be applied to activities on the critical path to shorten the critical path and, thus, shorten the time for the completion of the entire project. When a manager moves resources from activities on slack paths to activities on the critical path, we have a "trade-off of resources." These resources could consist of manpower, equipment, and/or money. In order for resources to be traded off, the resources must be interchangeable. Of course, the one resource that is always interchangeable is money.

THE COMPUTER AND PERT

The center of any large PERT system is the computer. It constantly computes any alterations and thus maintains the position of the current program's progress with emphasis upon slack times and critical paths. By processing the PERT statistics, the computer provides management with a timely, as well as accurate, series of reports that pinpoint the progress to date and predict the future of the project being planned.

• Changes in the critical path. There is nothing stable about the critical path of a PERT network. As the project progresses, the expected time will be replaced by the actual completion time for each activity. As discussed earlier, the critical path may also be changed by the reallocation of resources. As the critical path changes, the attention of management becomes focused on new events and activities. Thus, the big advantage of PERT is that it enables management to focus its attention on the activities and events which are the most critical for the completion of the project at any time during the actual work on the project.

• Dynamic progress reporting. The final component of the PERT system is the dynamic nature of its progress reporting system. Progress reports must be made to reflect any deviation from the original plans. As a result, those who manage the project will always be in a better position to correct problem areas before they threaten the achievement of the final completion date. The format and the frequency of reporting will vary according to the nature of the project, but a definite system of reporting must be established before implementing PERT. The original and all subsequent PERT reports dealing with the progress of the project should indicate the specific points at which corrective action should be taken by event, by activity, and by the total system.

• The use of the computer. One important advantage that PERT has over other management control techniques is its adaptability for use with the computer. The computer can calculate and print-out critical and slack paths. The significant point is that it can do this at any time during the progress of the project, taking into consideration changes in activity times and project completion times which may have been revised. Consequently, within a few minutes, the computer can provide management with updated earliest time (TE), latest time (TL), and slack time (t^1), as well as the critical path.

A graphic portrayal of a system that could be established to maintain an efficient computer-controlled PERT network operation is shown in figure 5-25.

ADVANTAGES OF PERT

It is quite obvious that the primary benefit of PERT is gained from the control which it helps to give the manager over all activities found in a complex project. The effect of alternative courses of action can be tested, and comparative analysis made as to what is to be gained by the use of a given course of action. A word of caution: PERT does not substitute for good management resources and ample finances. It does help to maximize the effective use of time and money in the following ways:

• It provides an exhaustive analysis of all tasks. This, in itself, is a tremendous asset of the PERT technique. Those in positions of responsibility are forced to take a closer look at all that is involved in a project. The continuing documentation insures that most "human oversights" are discovered and corrected during planning and during the actual project.

• The project's resources are maximized in terms of utilization. The manager has the necessary information to essentially allocate and reallocate resources based on where they are needed now.

• More accurate time estimates can be made. This facilitates managerial planning in terms of implementing the various phases of a project.

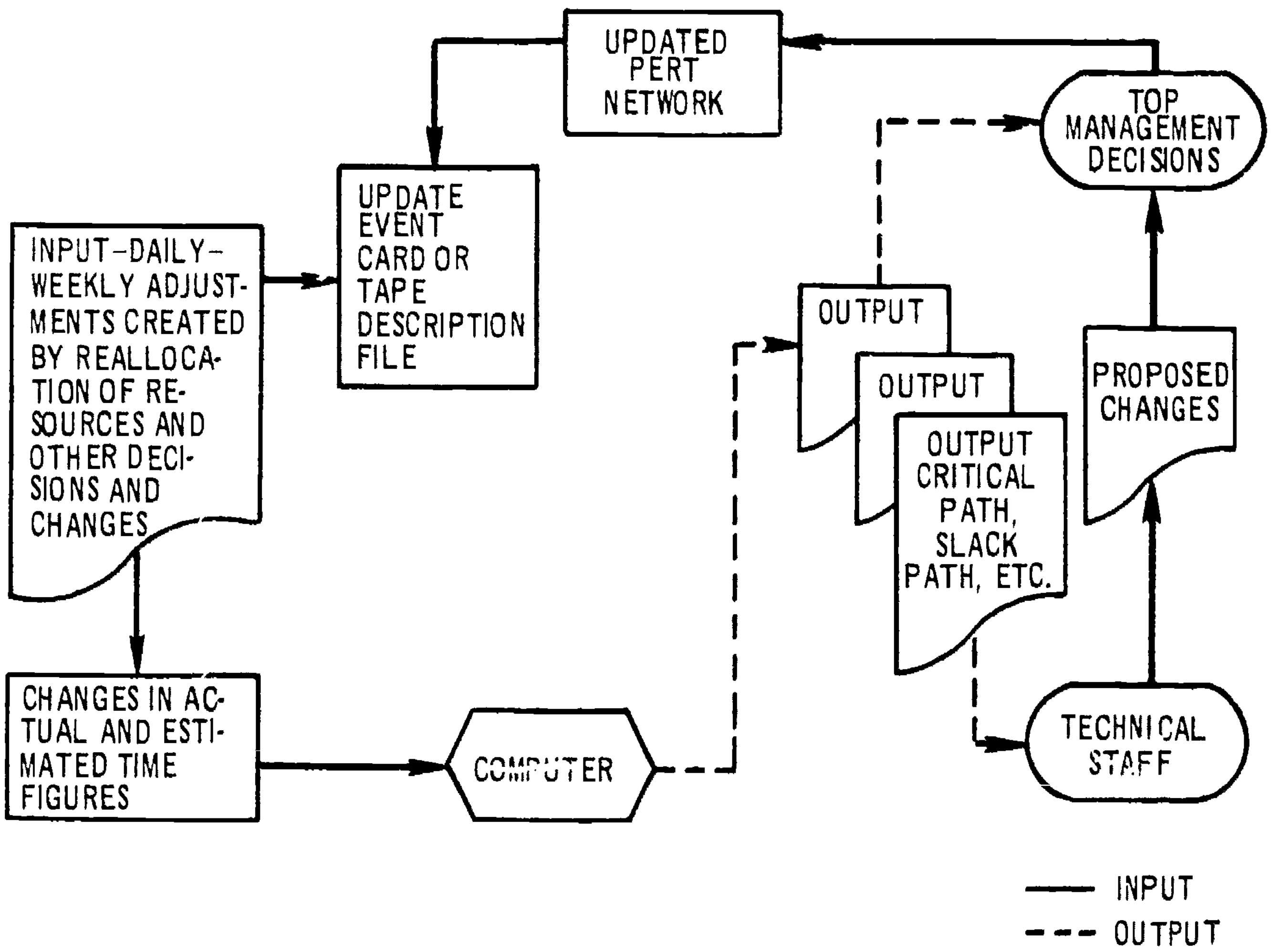

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Figure 5-25.—Computerized PERT system.

• PERT is relatively inexpensive. It has been found that PERT costs about twice as much as other control devices; however, savings effected by its use have offset many times its costs.

PERT is an excellent communication tool among all levels of management. Once understood by all, its limitations and unique terms insure that the various individuals are talking a common language.

SUMMARY AND CONCLUSION

SUMMARY.—PERT is a management tool that combines several management concepts including a network to represent plans, a time estimate to predict the time needed for each phase of the project, a measurement of the uncertainty involved in any project, and a means to continually revise the plans and operations. Its purpose is to provide the manager with instant information concerning the achievement of current objectives and to enable him to see what effect an event of a program will have on all the following events.

The following series of operational steps must be followed to make PERT an effective tool:

- Define the project.
- Develop a work breakdown structure.
- Construct a network diagram.
- Calculate earliest time (TE), latest time (TL), and slack time (t^1).
- Determine the critical path.
- Establish a reporting system.

Among the many advantages of PERT is its adaptability for use with the computer. Since the computer can determine critical and slack paths as well as make the other calculations needed to continually update the master plan, the value of PERT in this electronic age is increased.

CONCLUSION.—The use of the computer to control planning information provides management with a means whereby even routine functions can be identified if they are not carried out according to plan. Through the use of network techniques and computer speed, an accurate means of identifying exceptions can be made so that managers can more completely manage by exception. Consequently, managers and systems analysts will come to rely more and more upon the use of PERT. However, there is one danger that the user must constantly guard against; he must not become so involved in the mechanics of PERT that he overlooks its potential for planning and controlling the project itself.

SUPPLIES AND EQUIPMENT

Thousands upon thousands of dollars are expended in related equipment, office equipment, and consumable supplies required in the computer center other than ADP hardware.

Related equipment includes items such as carbon separators, magnetic tape cleaners, card file cabinets, control panel storage racks, and any other equipment peculiar to ADP installations. Office equipment refers to such items as desks, chairs, tables, typewriters, and adding machines. Consumable supplies consist of punch cards, continuous form paper, magnetic tapes, printer ribbons and so forth.

The procedures for procuring such items, and the method of payment, vary from one type of ADP installation to another, but normally the supplier offering service and quality plus a good price is usually the one selected.

Adequate attention to support items vital to the effective performance requires advance planning and continuing management to insure their availability at the appropriate time, and in the required quantity, and at the least expense.

Methods for identification, control and storage of supplies should be determined and a system of tape administration should be ready for use before operations begin.

The major problem with supplies is one of inventory. Unless the inventory is unusually involved, a manual inventory maintained with the aid of charts and orderly storage area may be the best answer. The data processing supplies worksheet illustrated in figure 5-26 may be used as a guide for maintaining a manual inventory.

MAGNETIC TAPE

The procurement, storage and control of magnetic tapes is an important phase of data processing. Normally, the tape library is part of the physical layout of the ADP facility and should be considered in the initial plans for facility modification. The library is more than a tape repository; it involves procuring tape reels of proper size and quantity, identifying and administering control and storage of tape reels, and maintaining the security of tapes.

An adequate quantity of magnetic tape reels in the library represents a large amount of money. Efficient use of magnetic tape reels is required to minimize the dollar investment and replacement cost; this should be worked out well in advance of actual operation. The number of tape reels required should be determined from analysis of application flowcharts, volume of data contained in each magnetic tape input and output file, and the number of history files required. The requirements for magnetic tapes should be carefully determined and procurement action initiated early enough to insure that adequate quantities of tapes are available to begin operations.

HANDLING, STORAGE AND ENVIRONMENT

Magnetic Tape

Magnetic tape used in data processing is generally a high quality Polyester best suited for computer application. Such tape, although of high quality, is sensitive to changes of temperature and relative humidity. Extreme changes of either temperature or, most importantly, relative humidity can cause the tape to alter in dimension and characteristic making it unsuitable for use. Magnetic tapes should be stored in their cases while not in use to protect them from damage, dust, and humidity changes. Empty cases should not be left open. Dust will contaminate the case and eventually the tape. Always carry reels by their hub and avoid bodily contact with the tape because body oils can cause contamination. Do not carry reels by the outer flange rims because this tends to damage the reel and the tape.

Stored tapes should be located at least three inches away from walls not air conditioned on the far side. This will prevent them from being

		ON HAND	ORDERED	RECEIVED
1.	CARDS FOR KEYPUNCH			
	(a) WHITE, MANILA			
	(b) BLUE			
	(c) OTHER			
2.	CODING SHEETS			
3.	TAB STOCK FORMS (PAPER)			
	(a) ONE PART LINED			
	(b) TWO PART LINED			
	(c) THREE PART LINED			
	(d) FOUR PART LINED			
	(e) ONE PART BLANK			
	(f) TWO PART NCR			
	(g) THREE PART NCR			
	(h) FOUR PART NCR			
	(i) OTHER			
4.	PROCESS SHEETS			
5.	TYPEWRITER PAPER (7080)			
6.	FLOWCHARTS			
7.	PRINTER RIBBONS (1403)			
8.	REEL TAGS, INDEX			
	(a) GREEN			
	(b) OTHER			
9.	ACCÓ FASTENERS			
10.	BINDERS (GRAY)			
11.	BINDERS (NOTEBOOK TYPE)			
12.	OTHER MISCELLANEOUS FORMS			

COMMENTS ____________________

SIGNATURE ____________

78.93X

Figure 5-26.—Data processing supplies form.

affected by moisture and thermal transmission through walls. Under no circumstances should tapes be exposed to magnetic fields because they influence data stored on tapes.

When tapes are removed from their conditioned environment they must be environmentally reconditioned before use. The recondition time must be equal to the length of time the tape was removed, but not more than 24 hours. Magnetic tapes stored at temperatures below 40°F and above 110°F (90°F for recorded tape) may be permanently damaged and, therefore, should not be stored outside this environmental range.

Disk Packs and Magnetic Cards

Disk packs and magnetic cards are affected by temperature and humidity as is magnetic tape and therefore require the same environment and handling as magnetic tape.

Paper Tape

The physical dimensions and characteristics of paper tape are affected by temperature and, most importantly, by humidity. Paper tape usually performs well when its environment is stable and the tape is conditioned to the use-equipment environment. Abrupt humidity changes should be avoided. Paper tape should be stored in the same environment as magnetic tape. Long term storage should be within environmental limits as indicated for cards below.

Cards

Punched cards are affected by temperature and humidity as are paper tape, paper documents, and printer forms. Environmental changes will affect the card's size and weight and may cause warping. This is a frequent source of card trouble in ADP equipment. A stable environment is therefore necessary to avoid any changes in the card's dimensions and physical characteristics. Punched cards usually perform well when their environment is stable and they are properly conditioned. Extreme changes of relative humidity below 35% or above 60% may permanently distort cards. Direct access from the storage area to the work area should be provided to prevent abrupt environmental changes.

When new cards are received, or used cards are stored outside the environmental limits, a period of acclimation is required. The period of acclimation required is dependent upon the difference of relative humidity between the machine room and the cards. Other factors determining the acclimation period are packaging, air circulation around cards and period of time cards were subjected to outside environmental limits. The following table may be used as a guide in determining the approximate time required to acclimate cards packaged in containers open to the machine environment.

Difference in Relative Humidity	Minimum Time Required for Acclimation
±10%	1 Day
±20%	10 Days
±30% or More	15 Days

New cards removed from their cartons should be lightly fanned to eliminate any tendency of the cards to cling together and to release possible static charges. Used cards should never be manipulated unnecessarily and should always be kept under pressure by a card weight either when being used or stored.

CHAPTER

PROCEDURE DEVELOPMENT

Before any ADP job is performed, a procedure for doing the job should be established. A procedure is a series of logical steps or operations by which the repetitive functions are initiated and performed to accomplish an end result for the job requirements placed on an ADP installation. A procedure normally specifies what work is to be accomplished, who is to accomplish it, and when the various steps in the process are to be performed.

Experience indicates the value of setting up and enforcing a body of procedures that can be followed on a routine basis for handling situations that recur frequently. These are mostly in the areas of input preparation, input handling, data storage, output handling, and console operation. In each of these areas, a diversity of operating procedures can be observed in different computer facilities. This diversity does not mean that any procedure will work well; it does mean that the choice of the procedure depends on the circumstances it is intended to meet as well as on the preferences of management. Where time pressures are strong, where deadlines are numerous, and where equipment is tightly scheduled, much more rigid operating procedures are found than where operations are primarily "open shop" (that is, programmers are permitted to operate the equipment), and few production runs are being attempted on the computer.

The operating procedures for a smoothly functioning operation must include clear and complete specification of the clerical procedures as well. This involves the preparation of detailed procedure manuals, giving precise directions as to how each person or piece of equipment is to operate in each situation. In general, these directions cover not only how to prepare the input in the required content and format, but they also cover such matters as sorting, proving, and converting the data and simple mechanical matters, such as how to get forms and materials.

Preparation of written instructions and training manuals are essential to the efficient operation of the system. Required instructions should be distributed to operating personnel in advance of actual installation to ensure that operating procedures are understood.

To maintain effective control of operations, it is essential that each application be properly documented with procedure manuals, wiring diagrams, flowcharts, and any other information that may be needed to begin processing. As changes are made to current systems, these revisions must be included in the procedure manuals.

Procedure development consists of documentation, flowcharting, preparation of office manuals, and card and form design.

DOCUMENTATION

Proper documentation is an extremely important responsibility of the Data Processing Technician in charge of an ADP installation. A tremendous amount of information and knowledge goes into the planning and operation of an ADP installation. In the original systems study the pertinent information on an application is collected and analyzed; in subsequent procedure development a great deal of new material and information is generated and used. Ordinarily, many individuals are involved in this process, and they cannot keep track of the innumerable details unless these details are recorded in a clear and orderly fashion. This means that the significant information must be written down and kept clear and concise. The creation and maintenance of these records—documentation—is a requisite for efficient and successful operation of the ADP department.

The information prepared for documentation should be reviewed and revised until it is sufficiently clear and complete to serve as the reference necessary during testing and conversion and after installation. Although considerable time must be devoted to preparing and maintaining complete, accurate, and timely records, the amount of time can be justified and is usually small when compared with the problems that can occur if proper attention is not devoted to documentation.

OBJECTIVES OF DOCUMENTATION

Documentation covers a wide area of ADP and accomplishes a number of things:

- It clarifies the scope of the job, identifies the methods used, and indicates the changes from previous operations.
- It aids in communication between ADP personnel and those in other departments.
- It serves as a necessary reference for the system and programming personnel who work on many different jobs over a long span of time.
- It provides flexibility in personnel assignment. Changes in personnel can be handled with a minimum of difficulty when the work has been well documented.
- It provides for communication between programmers and helps coordinate their efforts in related programs.
- It serves an important function in program testing and operation by providing the basic information for other individuals working with the program.
- It facilitates program modification.
- It helps in recording and evaluating installation progress.

Thus, adequate documentation is of prime importance in the planning and operation of any installation. Documentation standards should be defined early in the preinstallation period and firmly adhered to throughout the subsequent work.

HOW MUCH DOCUMENTATION?

In planning a system of documentation, it is important to determine just how much documentation is needed. Insufficient information may necessitate restudy of a job or complete reprogramming when modifications are required; too much documentation may become burdensome and inefficient. As a general rule, large organizations with large computers demand a more formal system of documentation than do smaller organizations with fewer personnel involved. Nevertheless, certain types of documentation are desirable with any size or kind of ADP system. Some of the features of effective documentation are discussed in the following paragraphs.

Current Working Value

The process of creating the documents and the documents themselves should be instrumental to and simultaneous with application and program development. If the documentation can be helpful to the data processing personnel in the working stages, it is far more likely to be used. Postponement of documentation often means that early considerations and decisions are forgotten; frequently, too, when a project has reached the operational stage, time is required for other tasks and the documentation is never completed.

Clarity and Intelligibility

To be of value, documentation should have maximum representation—that is, it should display the facts of a run in a clear manner. This would include showing the "big picture," emphasizing unique aspects, and providing a method by which all details of a run or program can be easily traced. Liberal use of diagrams, standardized symbols and programming techniques, consistent formats, and special forms are some of the devices that can assist in achieving this objective.

Ease of Alteration

Most programs are likely to change substantially during development and even after reaching the operational stage. An easy method of entering changes as they occur should be provided so that the documentation always reflects a true picture of the program. This helps not only in the making of revisions, but in the indoctrination of new personnel working with the program.

Organized Filing

A logical and orderly filing system should be used. This should include a clear system of arrangement and labeling and provide for easy reference to and maintenance of the records.

TYPES OF DOCUMENTATION

The diversity of programming projects at most Navy ADP installations necessitates a flexible documentation system which provides sufficient documentation for adequate communication. The following represents a fairly standard approach and can be adapted to specific needs.

APPLICATION MANUAL

A separate binder, with index tabs and designated sections, should be used to hold the material for each application. It should first contain a narrative which gives the objectives of the job, its scope, purpose, and other pertinent information necessary for a clear, concise description. This writeup can also describe the changes from prior procedures, the basis for the particular approach, and the sources for the information upon which conclusions were based. To support this and establish authority for the new procedures, a section should be provided for the correspondence, meeting reports, and agreements pertaining to the application.

Next, an overall system flowchart should be included. This chart displays the flow of data through the system, the sources of the data, and the processing steps required. Input should be clearly labeled, disposition of output shown, and controls and audit trails clearly indicated. A computer program identification code should be shown on the flowchart for cross reference. This code can be used throughout the entire system, including the program cards. The system flowchart is often augmented by a table of computer runs listing programs for the application and specifying the machine time required, volumes, schedules, and other pertinent information.

Record layouts, sample forms, and any other material necessary for clear understanding of the application should also be included.

Any procedures for manual or EAM processing pertinent to the application should be documented. This could be in the form of flowcharts along with the processing instructions. Forms showing keypunching requirements and their accompanying formats would be helpful here.

Figure 6-1 is an example of a checklist which can be used to help assure that all required documents concerning an application are available. Note that in this example the documentation for each program run is included in the application binder. More commonly, the runs are maintained in a separate run book as described in the following pages.

MASTER RUN BOOK

A separate run manual should be prepared for each major computer program or group of programs. It should contain all the information relevant to the programs and should be organized in a fashion similar to that of the application manual—that is, in a binder divided into sections, with appropriate index tabs, etc.

Most of the material required for the program documentation will be developed as a by-product of programming and testing.

Some of the questions to be answered by the run book are:

- What is the program?
- What does it do?
- How does it accomplish its function?
- Who wrote it?
- When was it written?

Careful documentation concerning these and the other products of the programming effort will greatly assist anyone in finding what he needs to know about the program. The following paragraphs describe the materials which should be included in the run book, shown in figure 6-2.

RUN DESCRIPTION.—A section should be provided giving the program identification, its function, the name of the programmer, names of other prople familiar with the program, input description and sequence, output description and sequence, controls, machine setup instructions, restart procedures, disposition of input and output, and any other information pertinent to the overall operating picture of the program.

GENERAL FLOWCHART AND DESCRIPTION.—A general input/output flowchart showing the input, main flow of the data, and the output of the program is needed. Along with this should be a narrative describing the run, giving its purpose, input and output requirements, and other pertinent information. In addition, the relationship of the particular program to the whole application should be indicated. This could be accomplished by including a portion of the overall flowchart of the application and outlining the specific run.

DETAILED FLOWCHARTS.—Current charts incorporating all changes and revisions should be included. The degree of detail should be commensurate with the need for adequate understanding and with the requirements defined by the installation's programming standards.

DOCUMENTATION CONTROL

APPLICATION ____________________

The following documents have been completed and are included in this binder:

DATE PLACED IN BINDER	FORM
________	Narrative write up
________	Overall System Flow Chart
________	Table of Computer Runs
________	Record of Management agreement
________	Due in - Due out schedules
________	Summary of Volume figures
________	Estimate of time by job
________	Samples of all input records
________	Forms to be prepared
________	Master disk layouts
________	Card forms

Documentation of the following programs is complete and included in this binder:

DATE PLACED IN BINDER	PROGRAM NO.	PROGRAM NAME
________	________	________
________	________	________
________	________	________
________	________	________
________	________	________
________	________	________
________	________	________
________	________	________
________	________	________
________	________	________
________	________	________
________	________	________
________	________	________

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Figure 6-1.—Sample contents of Application Manual.

RECORD LAYOUTS.—Detailed layouts of all records used in the program should be included. These would include input and output cards, master disk files, printed and typed reports, and a storage layout. The storage layout could be obtained from either preliminary planning records or from a machine print of the loaded program with the various areas of the program underlined and labeled.

SAMPLE FORMS.—Card and report forms used in the program should be shown, along with form numbers, approximate quantities, number of carbons, etc. Sample reports can

RUN BOOK (Contents)	RUN NAME			RUN NUMBER	
	ASSIGNED BY			DATE ASSIGNED	
	PREPARED BY			DATE SUBMITTED	
	APPVD BY	DATE	REVWD BY	DATE	SUPERSEDES

CONTENTS	NUMBER OF PAGES
A. RUN DESCRIPTION ABSTRACT	______
B. RUN INPUT/OUTPUT FLOWCHART	______
C. SEMIDETAILED FLOWCHART	______
D. INPUT RECORD DESCRIPTIONS	______
E. OUTPUT RECORD DESCRIPTIONS	______
F. MACHINE CAPACITY REQUIREMENTS AND PROGRAM DESIGN	______
G. SETUP AND OPERATING INSTRUCTIONS	______
H. MESSAGE LISTING	______
I. PROGRAM LISTING	______
J. LIST OF MEMORANDUMS	______
K. PROGRAM CHANGES	______

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Figure 6-2.—Sample contents of Master Run Book.

have actual information printed on them for the purpose of clarity. The carriage tape needed for the printer can also be included here.

PROGRAM LISTINGS.—A current machine listing of the source and object decks should be included. Any revision as a result of desk debugging or actual testing should be shown on the listings. (Since these listings do not fit easily into most binders, they are often bound in a separate larger one.)

PROGRAM HISTORY.—Initially, this can show the programming progress, such as assemblies, tests, etc.; later, it will contain the record of program maintenance and provide an audit trail by listing all modifications to the program. These should be documented by showing date, authorization, the addition or deletion, and the initials of the programmer making the change.

CONSOLE RUN BOOK

A run book should be set up for use at the console to assist in running the programs. It should contain complete operating instructions and other information required for normal operation of the runs. Many of the items included in the master run book described above can simply be duplicated and inserted in the console run book.

Some items that might be included are: A brief program narrative, checking of internal and external controls, program setup information, disposition of files, sample carriage control tapes, and printed forms, etc., and any information needed by the console operator to run the program.

The data in the console book should be organized in a form suited primarily for operator convenience and can be arranged either in a separate binder for each run, or in a binder for all runs in a particular application. For any occasion when more information than that contained in the console run book is needed, the operator should have access to the master run book.

FILE DESCRIPTION MANUAL

This manual contains a description of every file used in the system. It lists all record contents and formats, reasons for the formats, volumes, source, retention, uses, etc., and can be organized according to application, type, or whatever order would be most suitable. This type of manual has proved particularly helpful in installations using disk files.

DEPARTMENT MANUALS

In some instances, it is desirable to prepare manuals for the departments providing data for and serviced by the ADP installation. The contents of these manuals vary according to the needs of the individual departments. Such items as pertinent correspondence, sample reports, control requirements, scheduling information, volumes, and retention periods may be included.

OFFICE MANUALS

While on the subject of manuals, consideration must be given to manuals needed in the ADP installation other than just the data processing type. Authorized information dealing with the policies and practices of the installation; recommended systems, procedures, methods, and standards to be followed; and regulations can be given in a simple, direct, and uniform manner by means of office manuals.

Essentially, an office manual is a guidebook to assist in the orientation of personnel. Manuals relieve managers of having to repeat similar information, explanations, or instructions. Personnel come and go, but the manual stays. The training of newcomers is enhanced. The majority of nonusers of manuals are small facilities where informal communication and mode of operations may be considered sufficient.

Some of the basic types of office manuals include the following:

ORGANIZATIONAL MANUALS.—Organizational manuals give stability to an activity's practices and provide personnel with a ready source of information concerning duties, responsibilities, and authority under all conditions. When these factors are clearly understood, confusion and conflict within the organization are eliminated. Basically, the organization manual spells out who does what, and who is responsible to whom for seeing that "what" is done.

MANUAL OF POLICIES.—A policy manual puts into writing the policies of an activity concerning how the various phases of an installation's operations are to be carried out. The policy manual, normally, furnishes the background for an understanding of why things are done as they are.

MANUAL OF OPERATIONS.—Manuals of operation can serve as a convenient source for information on how the work is to be done. The authorized steps can be listed, and supplementary information, in the form of charts and diagrams, can be included in order to clarify the data. The standards and guides to be followed for individual tasks and jobs are included to inform personnel of established methods.

GENERAL INFORMATION MANUALS.—General information manuals are used to supply selected items from any area or subject deemed desirable and helpful in the work performance. This type of manual usually contains the rules and regulations of the organization.

CARD AND FORM DESIGN

To ensure efficient processing, cards and forms should be designed specifically for the application in which they are to be used. In doing this, it is necessary to:

- Know thoroughly the procedure and the machines to be used.
- Understand the reports to be prepared and know the use to which each will be put.
- Know the rules of good card and form design.

The application of these must be accompanied by ingenuity, common sense and experience.

Some of the rules and practical aspects of good card and form design are discussed separately in the following pages.

CARD DESIGN

Generally speaking, cards are categorized by their manner of preparation:

- TRANSCRIPT CARDS are punched from data previously recorded on another document. As a general rule, they consist of detail and master cards keypunched from a source document, such as diaries, vouchers, invoices, etc.
- DUAL CARDS are punched from data previously written on the cards themselves. Thus, they serve the dual purpose of both source document and processing medium, permitting an automatic means of sorting original documents.
- MARK-SENSED CARDS are those punched automatically from electrographic pencil marks that are recorded in mark-sensing positions on the face of the cards.
- OUTPUT CARDS are automatically machine-created as a result of processing disk storage records, tape records, and other punched cards. Examples include summary cards, new detail cards, or updated files. Some of these undergo additional processing for report preparation, while others replace the corresponding but outdated cards in a file.

Regardless of the manner in which it is prepared, in no case should a card be imposed upon a procedure; instead it should be designed for the particular use to which it will be put. This is the only way to achieve maximum effectiveness and efficiency.

Types of Card Data

All items of information placed in the card can be classified by any of the following three types:

1. REFERENCE identifies the original source document from which it was created, such as name, date, batch number, or activity processing code. The size of a reference field is determined by the largest single number item to be recorded. For example, names can usually be recorded in 20 columns or less.
2. CLASSIFICATION cross-indexes, classifies, or identifies a particular item on the source document, such as service number, part, or stock number, and social security number. Field size is readily established, as a set number of columns are always required.
3. QUANTITATIVE information consists of totals punched in the card that are to be added, subtracted, multiplied, or divided, such as quantity on hand or unit price. A realistic assignment of columns for totals can be made only if the maximum size of expected totals is known. Total fields are set up to take care of all but the unusual cases, and these are handled by punching extra cards for the overflow total. Assigning too many columns to a total field results in a waste of card columns, while a field that is too small requires punching of too many extra cards for overflow totals.

When determining the position of information on cards by the type of data, consideration is usually given to the following arrangements: reference information is placed to the left in the card, classification information in the center, and quantitative information to the right of the card.

Determining Card Data

The first step in card design requires a study of the final report that is to be printed from the card and a listing of the data needed for it. Next, the procedure is studied and any data needed for processing that is not also needed for the report is added to the same listing. Every item except that which comes from a table, master card and/or storage is extracted and recorded on a form similar to the one illustrated in figure 6-3. Provision must be made for recording in the card all data that is listed, unless it is calculated or generated.

CARD DESIGN WORK SHEET							
CARD NAME: DIARY					DESIGNER: DPC REYNOLDS		
INFORMATION REQUIRED FOR PROCESSING AND REPORT PREPARATION	FIELD SIZE				LOCATION IN OTHER CARDS	SEQUENCE ON SOURCE DOCUMENT	REMARKS
	TRIAL	TRIAL	TRIAL	FINAL			
NAME	19	19	19	19	26	2	
RATE	6	6	6	6	27	3	
SER. NUMBER	7	7	7	7	28	4	
ACT. CODE	5	5	5	5	1	1	

78.66X

Figure 6-3.—Card design work sheet.

A check should be made that the necessary reference data is included on the listing. The requirement for referenced data is to:

- Match the transaction and the original source document from which it was prepared.
- Indicate the occurrence date of the transaction.
- Establish reference data (such as batch number, service number, etc.).

The amount of reference data that is necessary is determined by the use to which the cards will be put and the reports which will be written from them. Care should be taken to avoid duplicate or unnecessary reference data.

Determining Field Size

The next step in card design is determining the field size of the data. Each type of information should be determined. The number of positions required to record each type of data should be determined and, if desired, could be recorded on the form shown in figure 6-3.

The field size for card codes is determined by the largest single number that is to be recorded. In determining fields for quantities and amounts, the size is set in accordance with the largest number that occurs on a favorable percent basis rather than on the largest possible number. If the amount is the largest it can be, which rarely occurs, consideration should be given to recording the transaction on multiple cards.

A listing is prepared showing all card data per transaction. If the number of columns required falls between 80 and 100, one of two courses is evident.

1. Considering the possibility of using two cards.
2. Reducing, by rearranging, the columns to be used to 80.

When using two cards sufficient reference data must be contained in the second card. When reducing the data columns, the following considerations are appropriate:

- Reduce, by recoding, the size of the reference fields. Several positions may be eliminated this way.
- Avoid the use of unnecessary data: for example, the use of both a rate code and rate abbreviation.
- Disregard unessential positions of reference data.

- Incorporate X and 12 control punches, located elsewhere, over numeric fields.
- Use code repetition more often; for example, repeat the batch number series each quarter as opposed to annual.

Determining Data Sequence

There are four major considerations in determining a card's data sequence. In order of importance, these are:

1. The location of identical data in other cards with which the new one will be processed.
2. The sequence of data on the source document from which the card will be punched.
3. The machines and/or programs to be used during processing.
4. The manual operations in which the card will be used.

Specific areas have been made available on the Card Design Work Sheet for recording the location of data in other cards as well as the sequence of the data on the source document. The effect upon sequence of machines and/or programs as well as manual operations and the location of interpreted information can be indicated in the remarks column. The completed Card Design Work Sheet is very useful in later design operations.

LOCATION OF DATA IN OTHER CARDS.—A given field of information in the new card should be placed in the same columns previously assigned to it in the other cards. This assures that sorting and controlling can be accomplished when the cards are processed together; it also facilitates control panel wiring and programming.

Figure 6-4 is a Multiple Card Layout form which should be used when planning several cards simultaneously or a new card that will be used with existing cards. The use of this form makes it possible to easily align fields which are common to more than one card.

CARD DESIGN RULES

A few basic rules must be observed in designing cards to take full advantage of machine characteristics and processing techniques. Some of the major factors include the following:

- Production rate is important; therefore, every effort should be made to punch the data on the source documents in the same sequence as the document is normally read.
- Fields to be duplicated should be grouped together and placed at the left end of the card.
- Manually punched fields should not be interspersed among duplicated, gangpunched, or computed fields.
- Locate numerical fields together so that keypunch operators need not change from one keyboard to another excessively.
- Any information, handwritten or printed, that is to be visually checked should be placed near the right or left end of the card so that it can be seen easily when the cards are fanned.
- Fields for recording mark-sensing marks should be placed on the right-hand side of the card so that the card can be held and marked easily.
- Corner cuts can be used effectively to distinguish cards types during processing and clerical operations. However, it is not recommended that the lower corner cut be used on cards that are to be keypunched.
- Give consideration to the use of prepunched cards.
- Anything which can be done to simplify the work of the keypunch operator will tend to increase the rate of punching and consequently reduce the time required for the preparation of management reports.

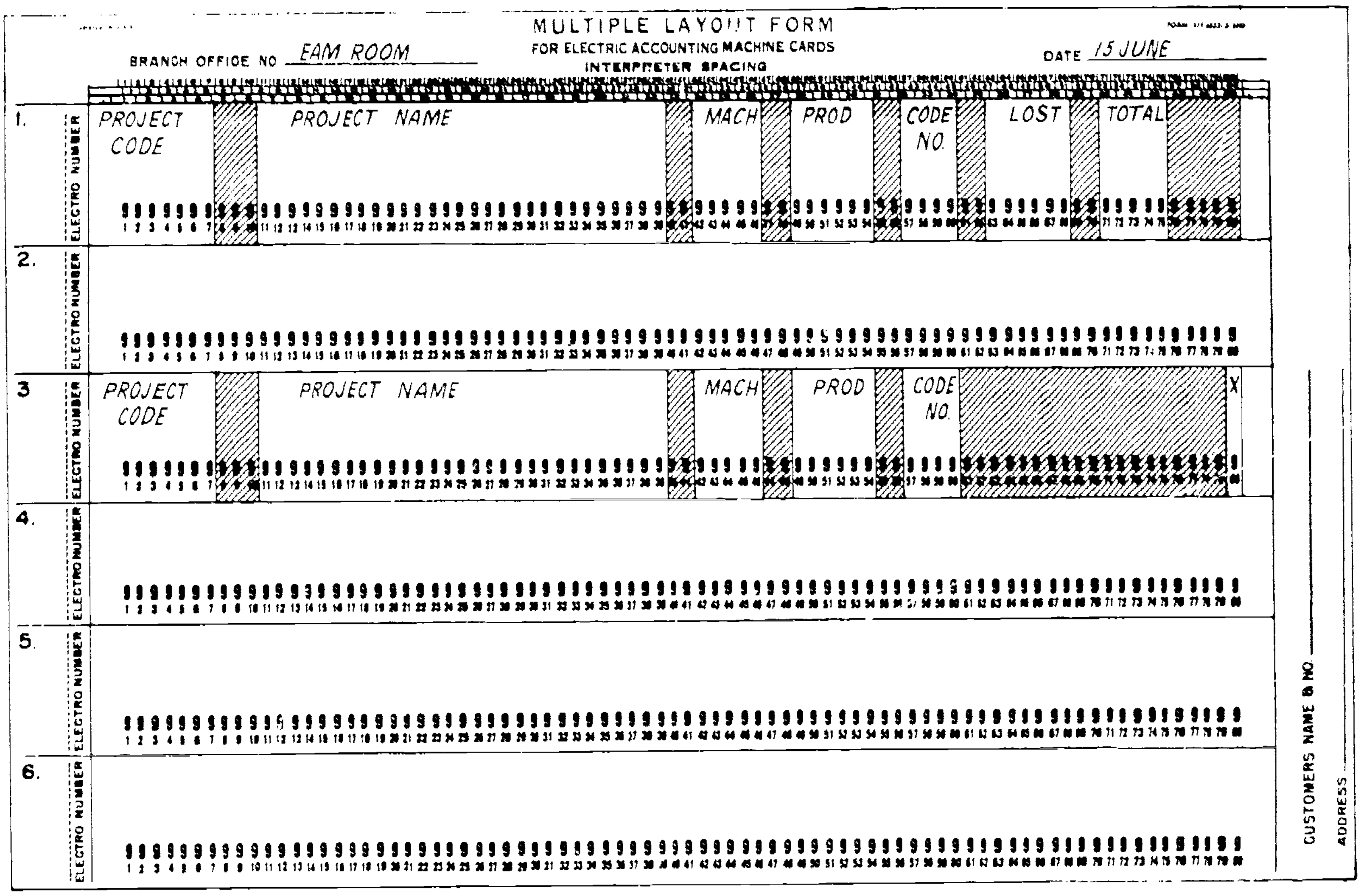
FORM DESIGN

A certain amount of evaluation and analysis is required to develop a useful form. It may be desirable to obtain the help of forms-design engineers for they are trained and experienced in this type of work. They are usually able to suggest improvements. Most manufacturers of forms offer the services of design engineers. This could eliminate many costly mistakes. The major objectives of good form design are:

- Legibility
- Simplicity
- Economy
- Efficient preparation

FUNCTIONAL CONSIDERATIONS

Functional considerations deal with factors such as the way the form is used, its purpose,



49.148X

Figure 6-4.—Multiple layout form.

the information supplied on it, and the number of copies required. Listed are some of the basic functional considerations in forms design.

PURPOSE OF THE FORM.—The foremost consideration is the purpose of the form. There may be existing forms which are similar to the proposed one and which, with minor changes, will satisfy the new requirements.

INFORMATION TO INCLUDE.—After the purpose of the form is determined, the next step is to decide what specific information the form should include. The tendency to burden a form with unneeded information is a great weakness of form designers.

SEQUENCE OF ITEMS.—Items should be placed on the form in a logical manner corresponding to the natural flow of work or information to be recorded on the form.

GENERAL PATTERN OF THE FORM.—Study the machine to be used for printing. The form should be spaced in accordance with the demands of the machine. In so doing, use the reference manual for this machine; most manuals have at least one section devoted to the tape-controlled carriage and/or form design. These sections contain valuable information about forms specifications as well as different printer characteristics and operation.

ADEQUATE INFORMATION.—The form must contain adequate identifying information as to its use and purpose.

Number and Type of Carbon Copies

The number of carbon copies should be carefully analyzed. Whether a single or multiple copy form should be used, depends mainly upon two considerations:

1. Who requires a copy?
2. When the copy is needed.

Multiple forms afford a quick means of supplying many copies as they only require one writing, minimize mistakes, help attain uniformities, improve departmental coordination, and save time. However, it is best to keep the number of copies to a minimum. Only the required number of copies should be prepared, as excess copies increase the cost of handling and distribution, and tend to clutter up an office and contribute to inefficiency.

Any report that is subject to constant usage should be prepared on a durable grade of paper. For most multiple-copy work, the first, or original, copy and the last copy are heavier in weight than the intermediate copies. Lighter weights of paper have less cushioning effect on the printing impact, and therefore, permit more legible printing on multiple copies. The paper must not be so stiff that it will buckle away from the platen. On the other hand, it must be of sufficient weight and strength to prevent tearing while feeding or ejecting forms.

The carbon used should produce the required number of legible copies without excessive smudging. Various carbon forms are in use. They include:

- One-time carbon—used only once.
- Carbon backing paper—the carbon surface is on all or part of the back of the original.
- Chemical coated paper—under the impact of the printing mechanism, the chemical coating on the back of one sheet reacts with the coating on the face of the other.

When the carbon is narrower than the form some method must be employed to keep the carbon in place. This could be accomplished by stitching, gluing, marginal perforations, or stapling. When staples are used they must:

- Be out of the print area.
- Be properly crimped.
- Not cause excessive bulging during feeding.

DESIGN CONSIDERATIONS

Depending upon its purpose and destination, the form on which a report is printed may range from the least expensive blank stock to the more expensive custom design.

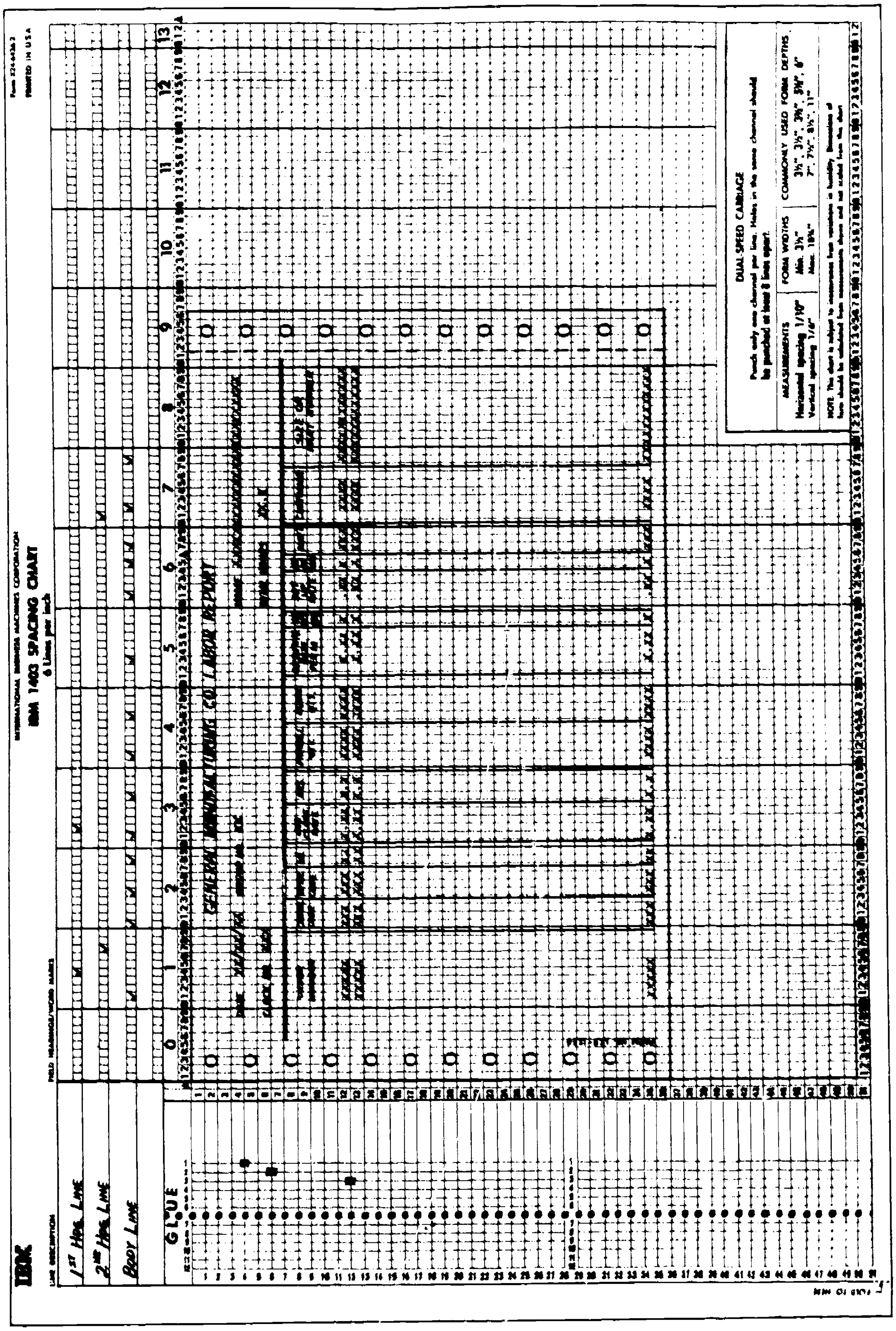
Reports printed on blank stock will probably be vague to outsiders unless the printer itself can be used to print column headings during report preparation. Imprinted stock forms are standard size forms which are stocked in large quantities and upon which lines, headings, markings and some designs are printed as desired. Custom forms are those which are designed to fill special needs of size, complexity and design. Although more expensive, they can be used advantageously to "advertise" the activity.

The form designer should understand and keep in mind, during the creation of a new form, the information contained in the following paragraphs.

DESIGN FORM LAYOUT.—Lay out the form on a spacing chart for the particular printer. A spacing chart for the IBM 1403 printer is shown in figure 6-5. These charts are available through each company's local representative. A few helpful pointers for using a spacing chart are as follows:

- Title the form.
- Keep heading small.
- Include form number and date.
- Avoid horizontal rulings if at all possible.
- Consider guide marks for names, addresses, and foldings.
- Consider total headings at the bottom of the form.
- Consider different-colored copies for routing.
- Use double-ruled lines to set off sections.
- Use bold type for heading.
- Allow sufficient printing space for amounts and punctuation.
- Place filing information near the top.
- If possible choose a standard form width.
- The form length and spacing to be used must be compatible.
- Include a form alignment guide for the printer.

FORM WIDTH.—When printing space for a new form is determined, the overall width is an important consideration. A great variety of form sizes can be handled by the various form feeding devices on the market. Still, there are certain aspects to be observed when standardizing the width of forms. A search of the particular reference manual will reveal the size of forms that the printer will handle. This should be compared with the standard sizes of forms printed by various paper stock companies. If at all possible, when designing a new form, the width should be confined to a width that is compatible to one of the paper stock companies' standard forms.



78.67X

Figure 6-5.—Spacing chart.

In addition form width standardization allows:

- More convenient form handling.
- A reduction in the setup time of form feeding devices.
- Purchase of report binding and filing supplies in fewer sizes and greater quantities at reduced cost.

FORM LENGTH.—In determining a form length the following rules should be remembered:

- The number of body lines for single-spaced forms can be any whole number.
- For double spacing the number of body lines should be evenly divisible by two.
- For triple spacing the number of body lines should be evenly divisible by three.

These rules apply to reports utilizing both 6 and 8 lines to the inch spacing.

HORIZONTAL SPACING.—Horizontal spacing is normally determined on the basis of printing 10 characters to the inch (consult the appropriate reference manual). The vertical lines separating fields and decimals of numbers should be drawn so that each splits a printing position. If they are drawn between adjacent positions, paper shrinkage, variations in form insertion and alignment, as well as other variables, may prevent satisfactory registration during printing.

VERTICAL SPACING.—The vertical spacing of most printers is under operator control and can be set for either 6 or 8 lines to the inch. The importance of this can be seen in figure 6-6.

Spacing at 8 lines per inch permits 33-1/3% more lines to be listed on a page than spacing at 6 lines per inch. While it is true that 8 lines per inch at SINGLE spacing gives more items than 8 lines per inch at DOUBLE spacing, the advantage of the latter is the double-spaced legibility.

FORM SKIPPING.—The maximum distance which can be skipped without losing machine

BOWDEN BILLY D	4435630	DPC
BRUEGGE HENRY C	6358159	DP3
CAMPBELL JOHN R JR	4900448	DPCS
CARTER JAMMIE D	4405658	DP1
COULTER FRANK J JR	5238223	DPCS
DEHAVEN ROBERT J	5211307	DPCS
DELGADO KENNETH F	3690721	DPC
GANDE LEE E JR	4884137	DPC
GRAHAM RAYMOND L	5137799	DPC
KELLER ALLAN G	5179836	DPC
KEMP RANDALL A	3494290	DP1
LANCASTER C E	4793176	DPCS
MCCAWLEY JOHN T	4168185	DPCM
MILLS SANDRA	6359688	DP2
MIRACLE GLENN W	4888918	DP1
MORRIS THOMAS A	4524597	DPCS
PERREGO MICHAEL L	5869693	DP1
PETERS RICHARD J	4511103	DPCS
REGISTER CLARENCE	6812835	DPC
REYNOLDS DENNIS R	5507771	DPC
STEIB JOHN F JR	6863643	DP1
THURMAN LESLIE H	3393251	DPCM
VEDAA ERLING L	5201841	DPC
YENNY CHARLES R	4736332	DPC

BOWDEN BILLY D	4435630	DPC
BRUEGGE HENRY C	6358159	DP3
CAMPBELL JOHN R JR	4900448	DPCS
CARTER JAMMIE D	4405658	DP1
COULTER FRANK J JR	5238223	DPCS
DEHAVEN ROBERT J	5211307	DPCS
DELGADO KENNETH F	3690721	DPC
GANDE LEE E JR	4884137	DPC
GRAHAM RAYMOND L	5137799	DPC
KELLER ALLAN G	5179836	DPC
KEMP RANDALL A	3494290	DP1
LANCASTER C E	4793176	DPCS
MCCAWLEY JOHN T	4168185	DPCM
MILLS SANDRA	6359688	DP2
MIRACLE GLENN W	4888918	DP1
MORRIS THOMAS A	4524597	DPCS
PERREGO MICHAEL L	5869693	DP1
PETERS RICHARD J	4511103	DPCS
REGISTER CLARENCE	6812835	DPC
REYNOLDS DENNIS R	5507771	DPC
STEIB JOHN F JR	6863643	DP1
THURMAN LESLIE H	3393251	DPCM
VEDAA ERLING L	5201841	DPC
YENNY CHARLES R	4736332	DPC

78.68(78B)

Figure 6-6.—Vertical spacing, 6 and 8 lines to an inch.

time is not the same for all printers. The time element should be considered after studying the appropriate reference manual. It is also advisable to study very carefully and determine the number of body lines which will occur most frequently. If the form provides for more or less than this number, valuable machine time may be lost in long skips or frequent overflows.

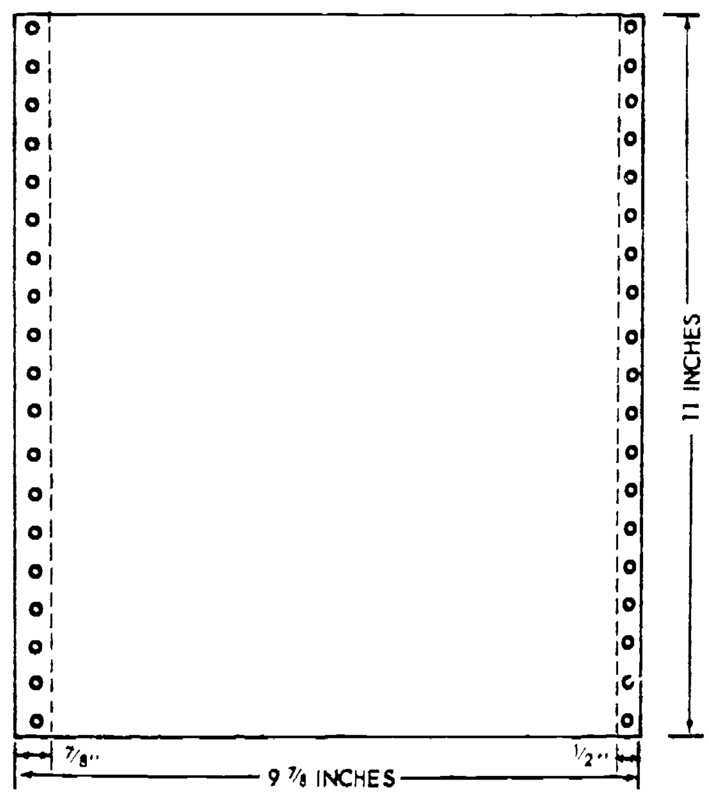
FORM ALIGNMENT GUIDE.—If possible, a guide for form alignment should be determined and preprinted on each form to facilitate machine setup operations. For most printers it can be a short line or mark in the margin or heading of the form; this line or mark should be used in conjunction with a stationary object such as a print line indicator.

It is important that a description of the form alignment guide and its use be included in the manuals of procedure. A delay in machine setup will create a delay in processing.

NUMERICAL AMOUNTS.—In determining the number of print positions needed for numerical fields, the size of the total must be provided for, rather than the size of the detail amounts. If marks of punctuation are to be machine-printed, the size of the field should be checked to make certain that printing positions have been allotted.

MARGINAL PERFORATIONS.—Generally speaking, vertical marginal perforations of most forms are 1/2 inch from each side. However this is not always true. Suppose we wished to have a letter size report after the marginal strips were removed. In this situation we would probably choose a form, similar to the one illustrated in figure 6-7, that has an overall length of 11 inches and width of 9-7/8 inches, with 7/8 inch perforation on the left and 1/2 inch perforation on the right. When laying out the printing specifications for a form, the distance equal to one print position should be left between the last character printed and the perforation. Since the form feeding holes can be used for binding, some forms are designed with no perforation on the binding edge.

BINDING.—Due to the cost of forms the binding space is usually minimized as much as possible. One way of accomplishing this is to place the information that is referred to least, nearest the margin, since it becomes increasingly more difficult to read information near the binder posts when many sheets are placed in a binder.



78.69

Figure 6-7.—Typical letter size report with perforations.

Many forms can be bound at the top without loss of readability. This is because of the amount of space required for heading information. Since it is desirable to bind continuous forms without the added cost of bursting them and binding them on the side, binding holes can be punched in both the top and bottom of the forms.

The practice of eliminating perforations and letting the form-feeding holes remain on both sides of the finished reports is being followed more and more, particularly with internal reports. Therefore, binders that employ the form-feeding holes are desirable.

FINAL TEST

The final step in form design should be a test in which a copy of the proposed form is used. In making the test, examine the report carefully to make certain that zeros are printing properly and that amount fields are large enough. Make certain that all possible conditions that can arise during processing are tested.

CHAPTER 7
SUPERVISORY CONTROL

As a supervisor in an ADP installation, you will be responsible for coordination of machines and personnel so that all jobs can be completed accurately, efficiently, and within the time limits allowed. Results of maximum value and minimum cost can be produced most successfully by observing certain good management practices and operational control. The type of controls discussed in this chapter will pertain to data control, operations control, and control of magnetic tape and program libraries. For effective control of an ADP system, all operations, data control functions, tape library functions, etc., should be well planned before the system becomes operational. The information presented in this chapter is not intended to establish rules and regulations governing layout and functions of control for any specific ADP system but rather to provide effective guidelines for setting up control for an ADP system.

CONTROLS

When plans and procedures are put into effect, a system of checks and balances must be established to ensure that results are produced in accordance with prescribed specifications. The production of timely and accurate reports and results is influenced to a large degree by the methods and systems established for controlling the flow of work.

Operational control consists essentially of maintaining control over source documents to ensure their availability and inclusion, ascertaining that data are processed correctly throughout all processing applications, and verifying the accuracy of results. These controls are not applied to a previously established procedure. Controls should be built into and become an integral part of every procedure during the planning stage. In setting up a system of controls for an ADP installation the following principles should be followed:

- Only those controls which satisfy a need should be established.
- The overall system of controls should be designed concurrently with the development of procedures. In this way, these controls will be an integral part of each data processing application and those areas which may have a tendency to be overcontrolled or undercontrolled can be detected.
- Personnel charged with the responsibility for maintaining controls should be familiar with ADP concepts and machine functions to enable them to locate, determine the cause of, and correct out-of-balance conditions.
- Controls should be simple and easy to maintain to avoid disrupting the flow of work.
- All control operations should be well documented and understood by operating personnel.
- Control operations should be mechanized whenever possible.
- When documents to be processed are batched, the batch size should be such that work will continue to flow steadily.
- Controls should be examined and reevaluated periodically. It is better to "over-control" in the beginning, as it may be possible to delete certain controls later.

The necessity of accounting controls generally increases with the volume of transactions and documents processed and the complexity of operations. However, the controls that are used should always provide a proper balance between their cost and value.

The controls discussed in the following paragraphs are of two types—those outside the ADP installation and those inside the ADP installation.

EXTERNAL CONTROLS

External control is the system of checks used to ensure the availability, accuracy, and inclusion of all input data required for execution of a job and to account for the proper distribution and disposal of such data. As a general rule, increases in the volume of documents processed and in the complexity of operations call for an increase in document control. The method used for controlling documents depends upon the type of documents handled and the processing procedures employed. The control techniques described are not limited in use to a particular application; they can or should be modified for use with different applications.

Document Register

Effective control of documents can be maintained by the use of a document register. Documents, as received, are posted on the register at the point of origin or receipt. Included on the register are sufficient data to identify each document such as serial identification number or description. The serial number is usually preferred over the description because:

- It provides positive identification.
- It is easily referenced.
- It is most easily used at the point of entry of origin.

In reference to figure 7-1, we can see that as each document is processed, the completion date is recorded. If the completion date is not recorded this signifies that the document is either being processed or is lost. Intermediate processing operations, such as, billing date, shipping date, and date received and audited may be recorded on the register as each phase of processing is completed.

Batch Control Tickets
and Serial Numbering

Batch control tickets provide a dual set of controls. When maintained in a file the batch control ticket illustrated in figure 7-2 provides accounting control for both the ordering and receiving sections. The ticket in figure 7-2 employs a document count as well as document and batch serial numbering.

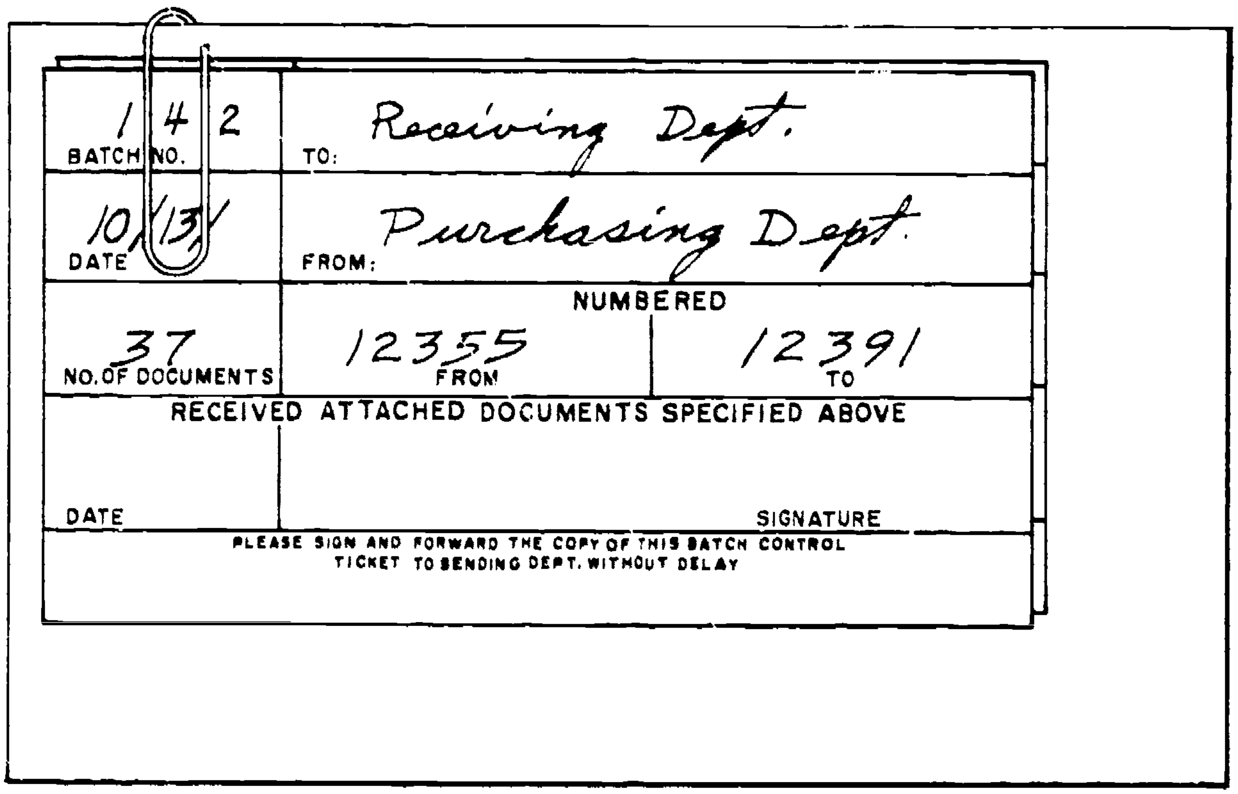
The serial number may be printed or stamped on each document. Checking for missing numbers as well as arranging in serial number sequence may be accomplished during as well as after processing to ensure that all documents are included or accounted for. This method is particularly adaptable to documents that must be accounted for. In the case of a punched card document, the serial number may be punched into and printed on the card. Then, checks such as sequencing, counting, and checking for missing documents may be accomplished automatically. Serial numbers may also be utilized for

DOCUMENT REGISTER MONTH October

DATE RECEIVED	ORDER NUMBER	DATE AUDITED	DATE BILLED	DATE SHIPPED	REMARKS
10/14	12831	10/14	10/18	10/18	
"	12832	"	10/16	10/16	
"	12833	"	"	"	
"	12834	10/15	10/17	10/18	
"	12835	10/14	10/16	10/17	
"	12836	"	"	"	
"	12837	10/15	10/17	10/18	
"	12838	10/14	"	"	
"	12839	"	10/15	10/17	
"	12840	"	"	"	
"	12841	"	10/16	10/17	
10/15	12842	10/15	10/17	10/18	
"	12843	10/16			awaiting spec. instructions
"	12844	"	10/19	10/19	

78.08X

Figure 7-1.—Document register.



78.71X

Figure 7-2.—Batch control ticket.

groups and batches. Here, the number of documents in each batch is recorded, together with the batch serial number, either on the first document of each batch or on a separate sheet accompanying the batch.

Transmittal and Route Slips

As documents are moved or transferred from one location or division to another, the responsibility must be fixed and control and transfer responsibility must be established. One method of affecting this responsibility is through the use of a letter of transmittal. The transmittal slip is usually a printed form describing a group or batch of documents, with sufficient space to indicate the variable information for the batch (fig. 7-3).

A route slip is employed to fix responsibility from one operation to the next or from one department to the next. Route slips are most often used when an application involves a large volume of work or a large number of operating personnel. The route slip shown in figure 7-4 is similar to a batch control ticket. It may be used independently or in combination, the route slip and letter of transmittal provide a means of incorporating a degree of work and document control.

Cancellation and Time Stamps

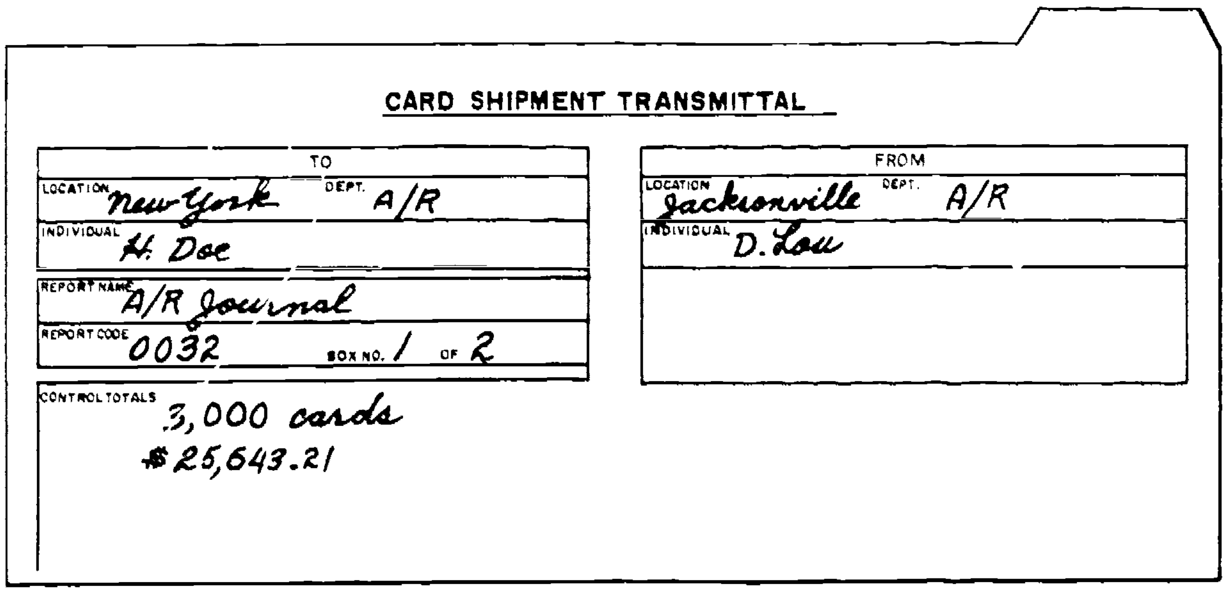
Document cancellation is the process whereby documents that pass certain divisions or work stations are stamped to indicate that they have been processed thus far. If an operator receives a document that has not been correctly canceled on the preceding step he would automatically reject or return it for checking. The use of time stamps for cancellation affords document control, a method of achieving work or production control, and an unalterable record of elapsed time for handling.

Matching

This is the process of reassembling duplicate copies to effect control. If the documents are recorded on punched cards this can be accomplished automatically; if not, it is a manual process of reassemblying, at the predetermined point, the multiple or carbon copies. Once matching is completed, the presence of all copies signifies that all processing has been accomplished.

Control of Changeable Factors

In every DP application there are factors subject to change. These could include hourly

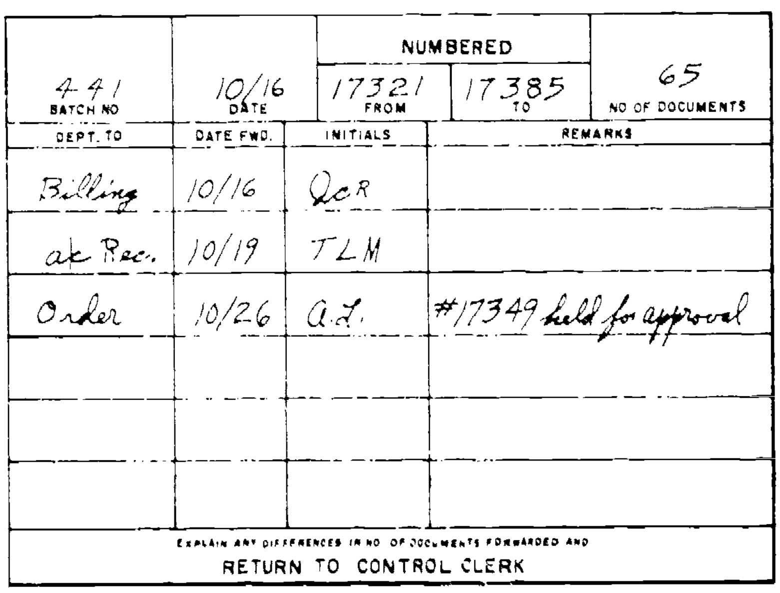


CARD SHIPMENT TRANSMITTAL

TO		FROM	
LOCATION New York	DEPT. A/R	LOCATION Jacksonville	DEPT. A/R
INDIVIDUAL H. Doe		INDIVIDUAL D. Lou	
REPORT NAME A/R Journal			
REPORT CODE 0032	BOX NO. 1 OF 2		
CONTROL TOTALS 3,000 cards $25,643.21			

78.72X

Figure 7-3.—Letter of transmittal.



BATCH NO	DATE	NUMBERED FROM	NUMBERED TO	NO OF DOCUMENTS
441	10/16	17321	17385	65

DEPT. TO	DATE FWD.	INITIALS	REMARKS
Billing	10/16	QCR	
ak Rec.	10/19	TLM	
Order	10/26	a.t.	#17349 held for approval

EXPLAIN ANY DIFFERENCES IN NO. OF DOCUMENTS FORWARDED AND
RETURN TO CONTROL CLERK

78.73X

Figure 7-4.—Route slip.

rate of pay, FICA, insurance, et cetera. But control must be estab'' 'ed to permit only authorized changes. ‘ne method for effecting this control is by a signature with each request for changes (fig. 7-5). A register figure 7-6 is prepared from the documented changes, with a copy routed back to initiating division for review and approval.

INTERNAL CONTROLS

Controls within the ADP installation are established to ensure that all transactions are processed completely and accurately. The series of checks and balances which make up these controls must begin at the point of converting source information into a machine-processable input medium and extends throughout all phases of data processing and output operations. Controls should be established for each of the three basic ADP functions—input, processing, and output—according to the needs for each function.

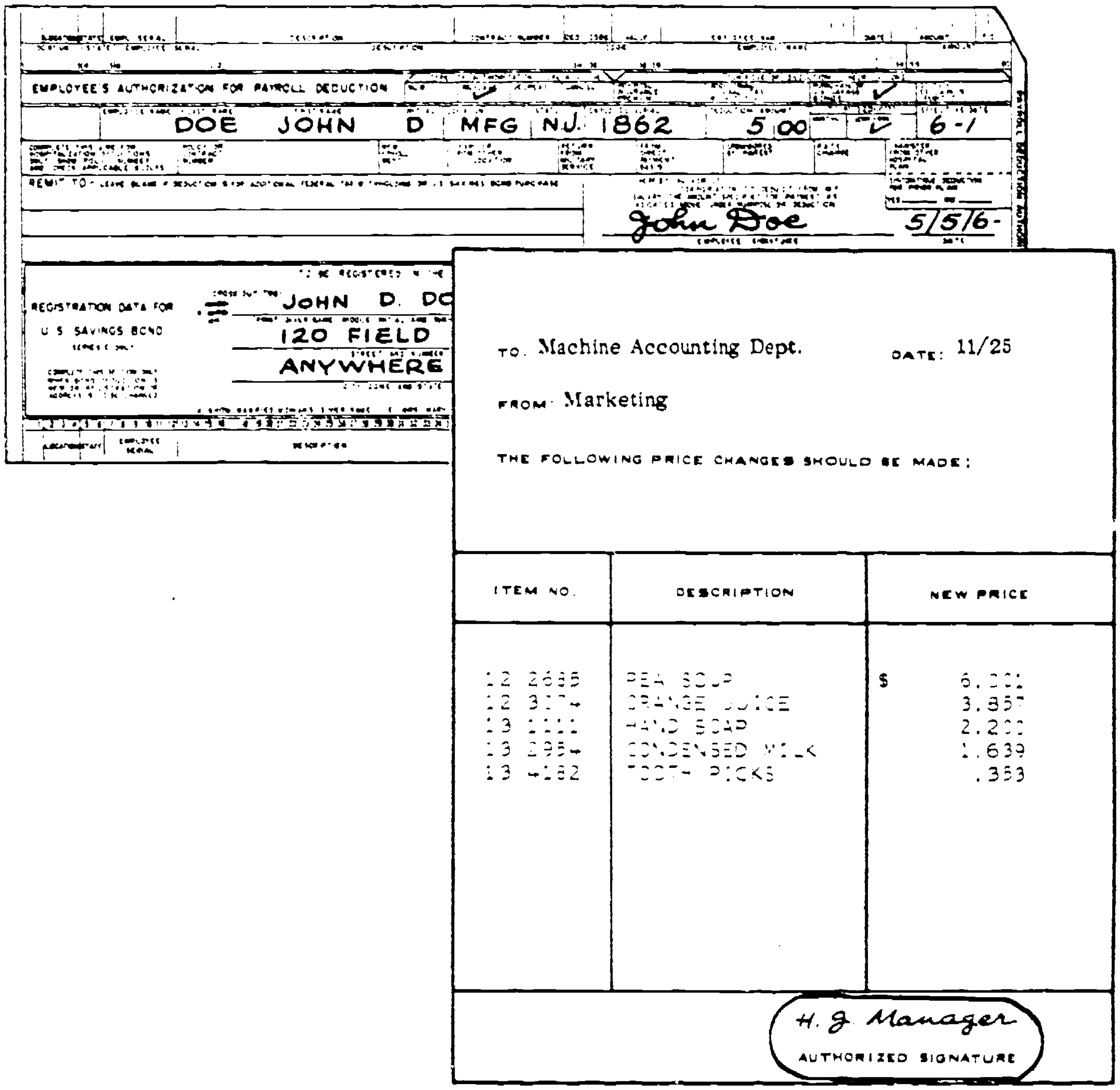
Control Techniques and Devices

Some of the control devices and techniques listed below may not be applicable to your particular need, but most of these can be incorporated into the procedures of any ADP system.

SERIAL NUMBERING.—The serial numbering of documents provides control while the data is in transit. Each item or document in the series or group is assigned a successive number; an indication of the beginning and ending numbers accompanies the group.

BATCHING WITH A DOCUMENT OR ITEM COUNT.—In batching data with a document or an item count, the items or documents are counted instead of numbered; an indication of the count accompanies the group. This method may be used to control data before as well as after punching into cards, if cards are used.

BATCHING WITH A CONTROL TOTAL.—In batching with a control total, some data field that is common to all items or documents is



EMPLOYEE'S AUTHORIZATION FOR PAYROLL DEDUCTION

DOE JOHN D MFG NJ 1862 5.00 6-1

John Doe 5/5/6-

REGISTRATION DATA FOR U S SAVINGS BOND

JOHN D. DO

120 FIELD

ANYWHERE

TO: Machine Accounting Dept. DATE: 11/25

FROM: Marketing

THE FOLLOWING PRICE CHANGES SHOULD BE MADE:

ITEM NO.	DESCRIPTION	NEW PRICE
12 2685	PEA SOUP	$ 6.001
12 3074	ORANGE JUICE	3.857
13 1111	HAND SOAP	2.200
13 2954	CONDENSED MILK	1.639
13 4182	TOOTH PICKS	.353

H. J. Manager

AUTHORIZED SIGNATURE

78.74X

Figure 7-5.—Change authorization.

CHANGE REGISTER

DATE	ITEM CODE	DESCRIPTION	FACTOR BEFORE CHANGE	FACTOR AFTER CHANGE
11-26	12 2685	PEA SOUP	5.956	6.001
	12 3074	ORANGE JUICE	3.132	3.857
	13 1111	HAND SOAP	2.253	2.200
	13 2954	CONDENSED MILK	1.652	1.639
	13 4182	TOOTH PICKS	.352	.353

78.75X

Figure 7-6.—Change register.

accumulated for the control total which then becomes the basis for balancing operations during processing. The control field may be an amount, item code, quantity, etc. The advantage of control totals is that balancing can often be accomplished during regular machine processing operations at no extra cost in time. These totals are commonly called "hash totals."

CARD VERIFIER.—The Card Verifier is used to check and verify card punching before the cards are processed in another operation.

CROSSFOOTING.—Crossfooting is the addition and/or subtraction of factors in a horizontal spread left to right, as opposed to top to bottom, to prove processing accuracy. This provides control on report preparation as well as calculating and card-punching operations.

ZERO BALANCING.—Zero balancing is used as an effective tool for verification of records. For example, when details and summaries are processed together the summary is added and the details are subtracted. If both are correct the result will be a zero balance.

NEGATIVE BALANCE TEST.—This method is used when it is desirable to know when the sign changes during an arithmetic operation. This condition may be known by stopping the machine or signaling the condition for subsequent review. One case which calls for a negative balance test is a payroll operation when the deductions are greater than the gross pay.

BLANK TRANSMISSION TEST.—This feature allows the checking of any data field for all blank positions. As a computer control, this test can be used to prevent the destruction of existing records in storage, indicate when the last item has been processed, skip calculations for blank fields or positions, etc.

REASONABLENESS TESTS.—Reasonableness tests provide a means of detecting a gross error in calculation or, while posting to an account, a balance that exceeds a predetermined limit.

COMPARING.—Comparing, as a control technique, permits data fields to be machine checked against each other to prove the accuracy of processing.

SEQUENCE CHECKING.—A sequence check is used to ensure that the data are arranged in either ascending or descending order for processing.

IDENTIFICATION.—Proper labeling of card decks, programs, and external or internal labels for magnetic tape also serve as a means of control. Identification reduces the possibility of mixing cards from different files, misplacing or losing cards, using wrong tape reels for a job, and destroying permanent records on tape.

PROCESSING CONTROLS

The number of available techniques indicates the need for a thorough study of the application and equipment in order to come up with a system of controls which is adequate but which does not overcontrol and delay processing. In so doing, it is desirable to mechanize as many controls as possible. Mechanized controls are always performed at a steady, rapid speed, whereas manual controls are not. An application study will reveal:

- How closely the application needs to be controlled.
- Points in the application where controls must be established.
- Corrective measures and restart procedures to be employed at each point, should out-of-balance conditions occur.
- How the responsibilities for accounting controls are to be divided.

A study of the equipment used for processing an application will reveal:

- The control techniques which will be most suitable.
- The possibility of mechanizing controls, and the extent to which possible, by control panel wiring or programmed instructions.
- The built-in controls which are available on the equipment.

As data enter the ADP installation the basis for establishing controls during processing is determined. These controls are normally established when documents are edited, and a system of controls is assigned such as serial numbers, document count, and control total. Once the preliminaries are taken care of, the transactions are ready for processing.

The primary control objective, during report preparation, is to prove that all required items are included in the processing and that arithmetic is performed accurately. When operations are proved as they occur, it can be assumed that the data themselves are correct.

A final control total may be developed during processing and balanced to a control total obtained at the end of a report to verify the inclusion of all required items. The control total may be a hash total of all account numbers in a report, the total for a given amount field for all records, or a similar type of total. For control of arithmetic functions which occur during report preparation the following techniques should be investigated:

- Crossfooting
- Total transfer
- Zero balancing
- Parallel balancing
- Reasonableness or limit test
- Combination(s) of above

BUILT-IN CHECKS AND CONTROLS

Built-in checks are essential in every ADP operation. Those functions, built into machine circuitry and performed automatically, should not be duplicated by either manual or programmed controls. Some of these checks are common to all machines. For example, all machines have checks which stop the machine for a timing error, a blown fuse, or an operation that is impossible or in conflict with another. For more information regarding built-in checks, refer to the appropriate machine reference manual. However, some of the internal checks built into most computer systems include input/output checks, instruction checks and parity checks.

INPUT.—The input check ensures that all data is read and coded correctly into machine language.

OUTPUT.—The output check ensures that the output characters are correctly set up for punching and printing.

INSTRUCTION.—The instruction check permits the execution of only those instructions having a valid operation code and instruction format.

PARITY CHECK.—The parity check verifies each character in the computer on the basis of an odd or even bit configuration. In magnetic tape operations each character and each channel within a record must pass a validity check for an odd or even number of bits; the system determines whether the bit count is odd or even. This prevents loss of data.

As built-in checks, transfers to the systems output devices are parity checked and the devices themselves have checks. Most card punches have a hole count check, printers have setup checks, and tape units utilize a dual-gap head so that validity checking is performed immediately after writing.

THE AUDIT TRAIL

An audit trail is a must for every procedure, and should be considered an integral part of the procedure. In creating an audit trail, provision for it should be made in the early stages of procedure development. To provide an effective audit trail provision must be made for the following:

- Documentation of transactions in enough detail to permit the association of any transaction with its original source document.
- A system of accounting controls which proves that all transactions have been processed and that all accounting records are in balance.
- Transactions must be documented so that they are easily recreated and their processing continued, should some of the forms become misplaced or destroyed at some point in the procedure.

Due to the varied job requirements in the Navy, a detailed discussion of the various methods employed for audit trails will not be covered here.

PROCEDURE CONTROL

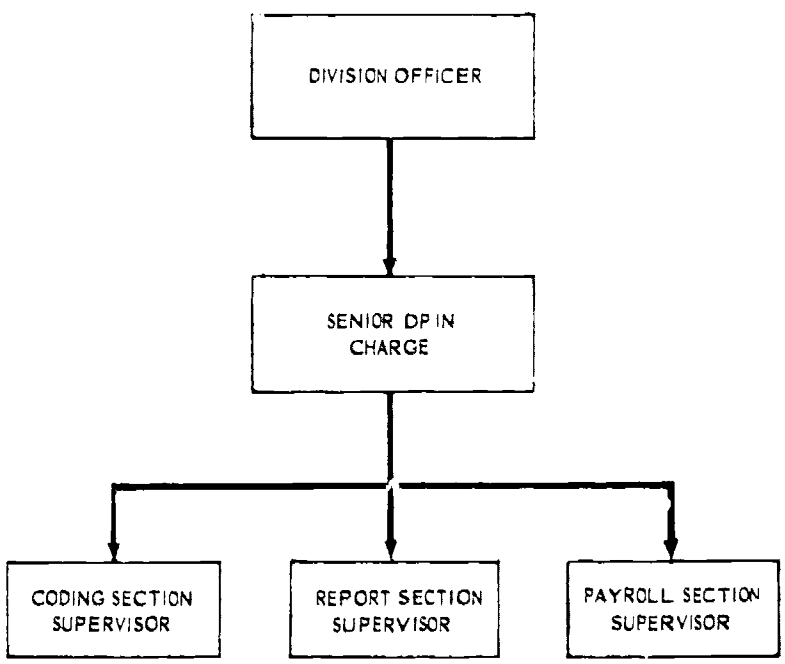
Good operating procedures constitute the guidelines required for seeing that all job requirements are performed in the proper fashion and that the desired end results are obtained. The development of procedures is not enough however; the supervisor must keep close check on the work in process to determine if jobs are being performed in accordance with job specifications. Operators too frequently fall into the habit of ignoring job procedures once they feel they have mastered the job. Consequently, they may develop "short cuts," disregard checking and balancing procedures, and be unaware of changes which have been made to the operating procedures. The practice of not adhering to the sequence of job steps may result in improper output, and precludes an accurate determination of the progress which is being made on a particular job assignment.

Operators should be instructed to check with their supervisor when they feel they have discovered a better method of accomplishing certain job steps, or when they detect any discrepancy in operating procedures. In this way, procedures can be maintained which will most usefully serve the purpose for which they are intended. Any changes made to operating procedures, machine setups, record layouts, and any other changes which affect the outcome of a job should be brought to the attention of the operators concerned at the time such changes are placed in effect.

Supervisors often are asked by intended recipients of data processing services just when a particular report will be available. Vague replies such as "sometime this week" or "when we get around to preparing it" not only give the impression of independence on the part of the supervisor, but also indicate that the supervisor does not have the proper control over operations for which he is responsible. Good personnel relations and positive control over data processing operations are essential ingredients of an efficient data processing organization. Thus it behooves the supervisor to know the status of any given job at any given time. The schedule of reports is useful in determining which jobs have been completed and which jobs are not due to be started, but it does not provide information concerning work in process. The controls for determining the work in process follow no set standard, but rather are dependent upon the size and complexity of job assignments. For small jobs, a notation of the time a job was started and reference to records which indicate the time required for the same job on previous occasions may be sufficient to make a good estimate as to the time the job will be finished. Larger jobs, especially those which may take several days to complete, may require more positive control; that is, notations as to the time major phases or particular steps in the procedure were completed. Thus, a realistic estimate as to when a job in process will be finished can be provided by reference to the time a certain stage in the procedure was reached plus reference to previous time requirements from that point on. Scheduling will be discussed in detail in the following chapter.

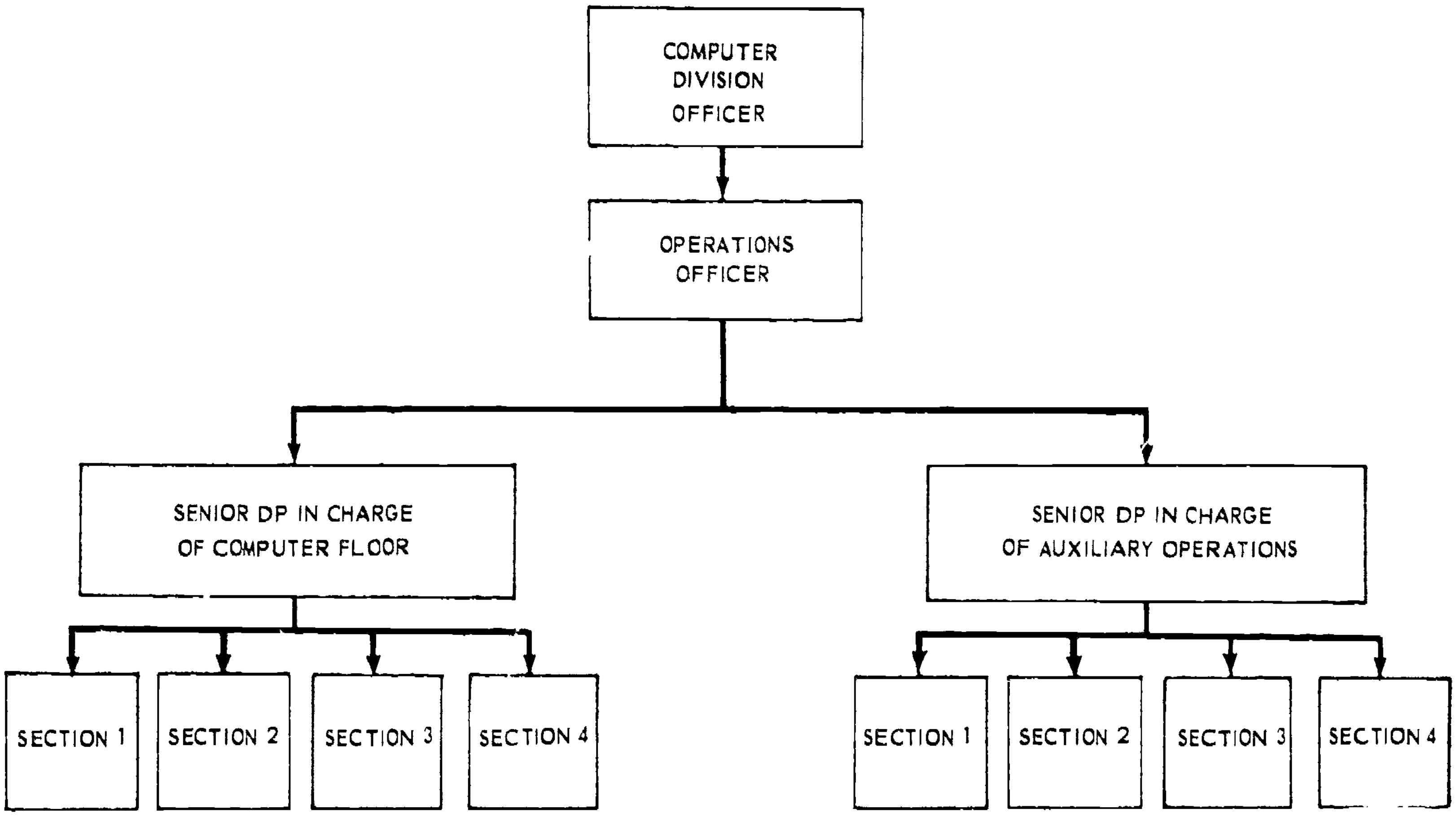
CONTROLLING THE OPERATION

All operations pertaining to data processing are subject to rules and regulations. Aside from physical operating procedures, the two most important areas are data control and computer operations. The controls may be established in accordance with the mission of the installation. Another consideration is dependent on the size of the operation. For instance, a small EAM installation may not need a data control division (fig. 7-7). You will notice that the entire installation is controlled by one senior Data Processing Technician in charge; the work flow and load are of such a nature that data control need not be separated. Another example may be seen in figure 7-8; this is one method of controlling the operations of a small computer installation. You will notice that there is an additional officer who serves as operations officer or liaison. It is conceivable to have two Data Processing Technicians in charge; one in charge of the computer floor; the other of all auxiliary operations. Again, it is possible for the senior Data Processing Technician in charge of each area to coordinate the activities of the center and users without a data control division. But, as systems become larger and more complex, the need arises for a data control division. Figures 7-9 and 7-10 depict two examples of how the control could be designated. Because of the many different operating systems our discussion will primarily be concerned with the data control division which includes controls concerning input data, output data, processing,



78.78

Figure 7-7.—Controlling a small EAM installation.



78.79

Figure 7-8.—Controlling a small EDP installation.

quality, scheduling, library functions, programming, coding, and physical layout of controls.

PHYSICAL LAYOUT OF CONTROLS

The designated control area should be so located that it lies across the natural path of input to the computer. The designated control office should be near or within the computer area. If space availability is not sufficient within the computer room, it should be located as close as possible to it. In the case of the latter, door or window openings may be utilized for access from the control office to the computer room. A terminal point, table and/or counter, should be specified for the delivery of material by the control section. Likewise, a pickup area must be designated.

Operators for the system should not have to pick up jobs, or deliver completed jobs, at a remote point. Here again, if space does not permit close proximity, it may be feasible to utilize a type of conveyor belt to transport the input and output to and from the computer.

If space permits inside the computer room, the control office may be laid out in such a manner that area for input and output may be designated to eliminate excessive walking for both operators and control personnel (fig. 7-11). The area between the entrance and the computer is best suited for the control office. Whatever arrangements are made, working storage space must be provided in the control office for:

- Tapes
- Cards
- Forms
- Office supplies

DATA CONTROL

Controls are the mechanics for achieving a smooth flow of work between the users and the computer center, as well as to, from, and between the machines to avoid undue periods of idleness of personnel and equipment. Data control is necessary to achieve the fastest turnaround. Figure 7-12 illustrates a simple work flow pattern for a large EDP installation. You can see that, in this organization, the data control division is responsible for everything

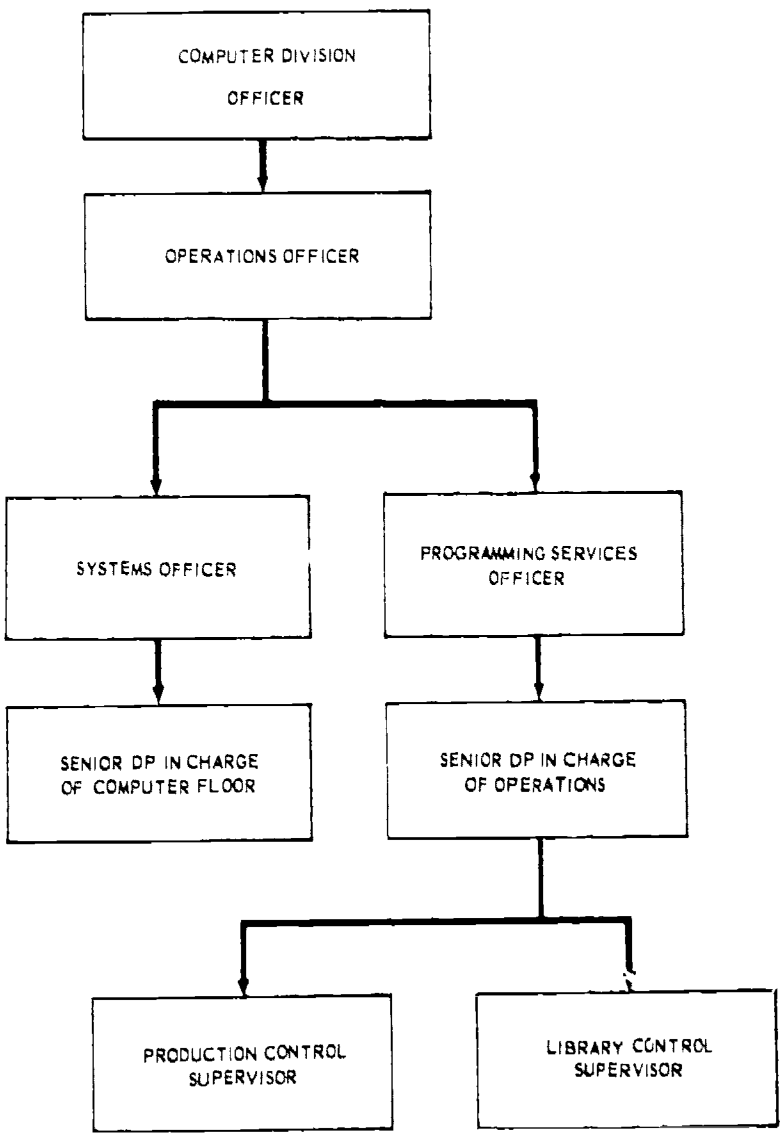


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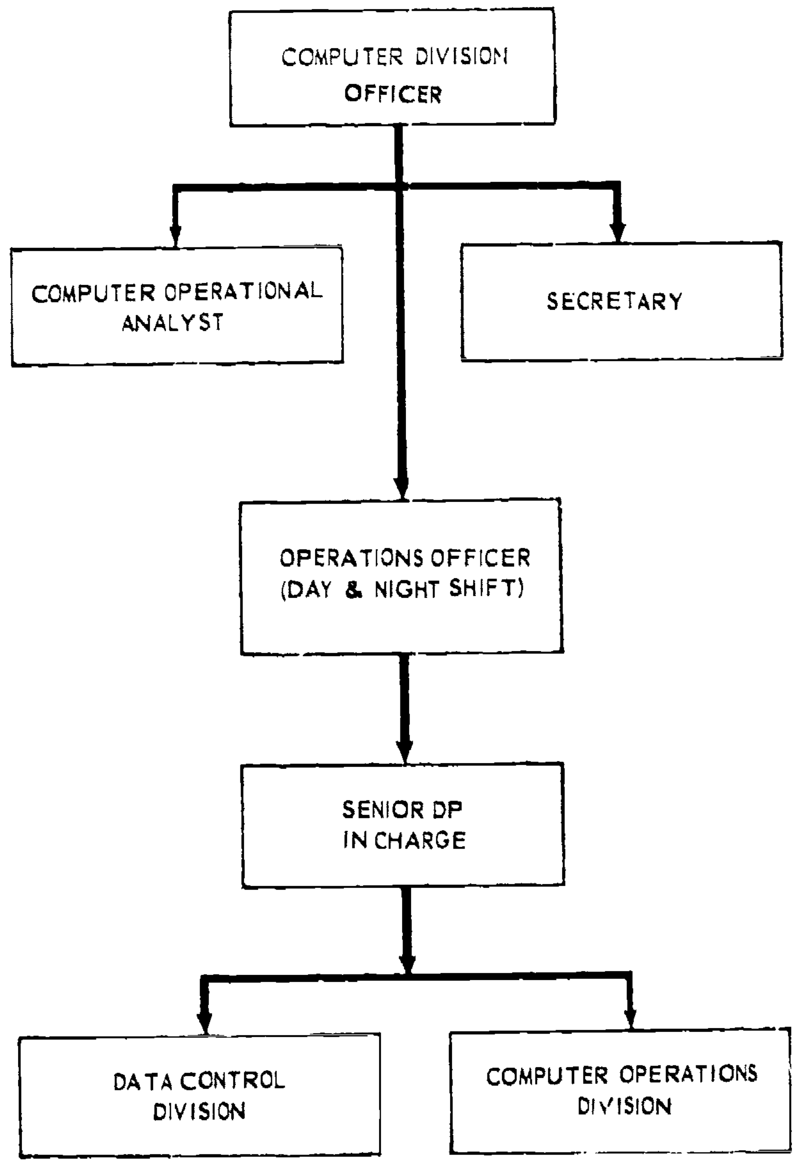
Figure 7-9.—Controlling a large EDP installation.



78.81

Figure 7-10.—Organizational control for a large computer center.

except the equipment operation. This is not always the case. For instance, a quality control supervisor could be assigned for each system and perform his job on the computer floor.

Data control serves as liaison between the EDP installation and the user, controls the flow of work within the center, and exercises control on the quality of output. In the absence of a data control division, the supervisor is called upon to perform the following tasks:

- Receive the work
- Plan the work flow
- Check the computing process
- Regulate the workloads of machines and operations
- Prepare the work for more efficient processing

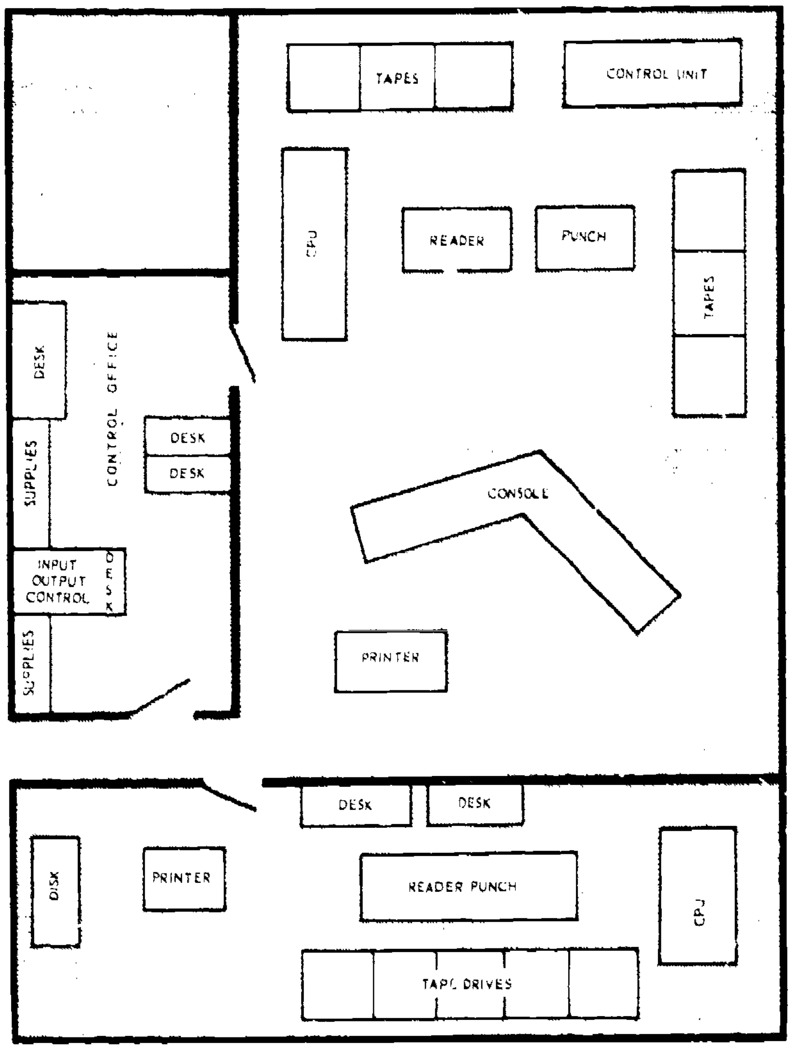
CONTROL FUNCTIONS

There are many areas to be considered when planning control functions of a computer center. The primary areas of control are:

- Material handling
- Routing
- Transporting
- Quality control
- Production control
- Scheduling

In addition, control functions are responsible for the progress of all jobs, correction of errors, and running all production runs.

Data control serves a dual function in a computer installation. First, it serves as an entry



78.82
Figure 7-11.—Typical control office.

and exit point for all computer related work. Secondly it is the responsible authority for breaking the job up into tasks, assigning the tasks to appropriate groups, and scheduling the tasks.

The control point or office of an installation serves as a contact and liaison point between user and installation. To perform all of the control functions efficiently, the data control division must be well organized. A typical data control division may be organized as follows:

- Chief, data control division
- Data retrieval specialists
- Data control clerk (job scheduler)
- File specialists
- Security clerk (if required)
- Couriers (if required)
- Tape librarian
- Keypunch operators
- Time utilization clerk

The functions of the above mentioned specialties are described in the following paragraphs.

DATA CONTROL DIVISION CHIEF AND SHIFT SUPERVISORS.—The data control division chief and shift supervisors are responsible for:

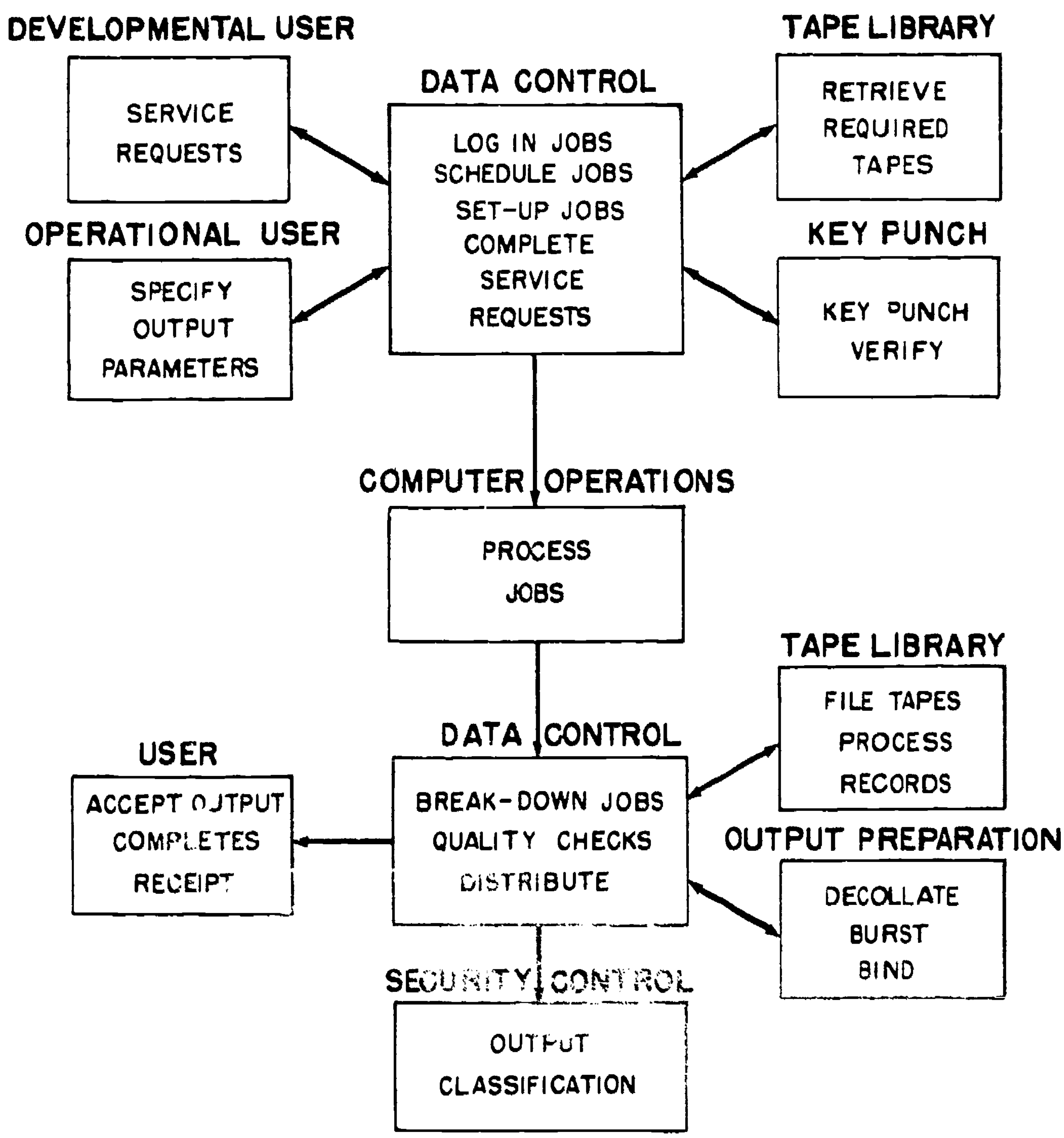
- Supervision of the data control division work and coordination with the computer operations division.
- Data control division personnel training.
- Assisting others to meet difficult technical problems and unusually heavy workload.
- Planning and scheduling of work.
- Assuring that classified material is properly controlled as to input, processing, and output.
- Reviewing and evaluating operations, and preparing reports for management.
- Reviewing and revising standard operating procedures.
- Resolving personnel problems, personnel evaluation, and other personnel functions.

DATA RETRIEVAL SPECIALISTS.—The data retrieval specialists are responsible for:

- After consulting the user and operations officer, preparing the request form for "Special Information Retrieval."
- Coordinating with the operations division and the operations officer the interruption of normal operations.
- Utilizing the required format, system query via remote console.
- Ensuring the user's satisfaction by reviewing the output with him; modify, query, and resubmit if necessary.
- Maintaining a detailed, up-to-date knowledge of the inquiry system as well as data files and elements that can be queried.
- To facilitate problem solutions, maintaining contact with the system analyst and file specialists.

DATA CONTROL CLERK.—The data control clerk (job scheduler) will have the general responsibilities of manning the customer service desk, and is responsible for the following duties:

- Receive and process all requests for service.
- Assemble and set up all incoming work.



78.83

Figure 7-12.—Computer center work flow.

- Distribute all outgoing work.
- Schedule production runs.
- Post changes to the production run books as directed.
- Maintain the computer center's job control desks.
- Ensure that recipients of classified material have signed the appropriate control card.
- Perform the functions of the security clerk when he is absent.
- Control access to the computer operations area.
- Identify and document "priority overruns" on the service request.
- Other duties as may be assigned by the appropriate supervisor.

SECURITY CLERK.—The security clerk (if required) will have the responsibilities of maintaining control of all classified data leaving the computer center. He will:

- Prepare for all classified data a classified data control record card.
- Decollate, burst and bind all printouts if required.
- Maintain files of signed control cards, updating the files as certificates of destruction are received.
- Perform the tape librarian tasks when he or she is absent.

TIME UTILIZATION SPECIALIST.—The responsibility of the time utilization specialist is to ensure, through daily and monthly reports, that management is fully informed of the computer(s) utilization. He prepares and distributes daily and monthly reports for each computer by both clock and meter hours. He prepares management reports which include every time card by job number and show meter time, clock time, distribution of clock time, and difference between clock and meter time for each job.

Additionally, he is responsible for maintaining the required charts, including an efficiency rating chart and a maintenance chart.

TAPE LIBRARIAN.—The primary task of a tape librarian is to maintain the computer center tape library. The duties of a tape librarian will normally encompass the following tasks:

- Retrieve and file magnetic tapes when requested by the job scheduler or other duly authorized personnel.
- Maintain tape files including physical inventory and other related files.
- Initiate and control the use of indexes, logs, tape labels, and associated files.
- Prepare tape usage reports from accumulated tape usage data and make recommendations concerning the disposition of faulty or wornout tapes.
- Maintain control of certain required data and program files.
- Maintain file of completed computer service requests and related material.
- Pretest new tapes for quality, clean tapes, and degauss tapes according to schedule or upon release by programmers.

KEYPUNCH OPERATORS.—Keypunch operators will be responsible for the following areas:

- Keypunch and verify data according to the required instructions.
- Maintain work area and equipment in a neat and orderly condition.
- Perform any other tasks that may be assigned by the supervisor.

PRODUCTION CONTROL

Production control (same control function as a data control division of another activity) is an important responsibility of the control function. Production control requirements depend upon the type of work processed, the users environment, and character of the entire installation The control point or office in a Navy installation is often referred to as production control or data control division. We have previously covered the organization and functions of an installation utilizing a data control division. Let's look at an example of production control. In this case, the control functions remain the same, but some of them have moved from the control office to the computer floor.

In some installations production control personnel may be charged with the responsibility of only logging in and out programmers run requests. But their responsibility could encompass the following areas:

- Material handling—in case the control office maintains supplies; cards, forms, tapes, et cetera.
- Routing—in case the installation houses more than one system.
- Transporting—in case this function is assigned to the control office.
- Quality control—when the function is assigned to production control.

A typical user/computer cycle will be discussed in the following paragraphs.

Normally, the first contact a user has with a data processing activity is a work request (fig. 7-13) for the punching of his source program. You will note that the request is self-explanatory. In this case the programmer wants the source program punched, verified, interpreted, and listed. In addition, sufficient information is provided to identify the classification of the program, programmer's name, and location.

Once the source program has been punched and the required desk checking functions completed, the programmer can prepare the program for its initial run on the computer.

For identity, let's assume that the program is to be assembled, the project number is 9059060,

PUNCH SOURCE PG DECK   DATE 11-30-6-

X	KEY PUNCH	X	LIST
X	VERIFY		NO. OF COPIES 1
	REPRODUCE		COLLATE
X	INTERPRET		MINOR
	UPPER (1-60)		INTER
	LOWER (61-80)		MAJOR
	SORT	REMARKS	
	MINOR		
	INTER		
	MAJOR		

CLASSIFICATION

[X] UNCLAS [ ] CONF [ ] SEC [ ] TS

PROGRAMMER	PHONE EXT.
Mike Asbill	83351

78.85

Figure 7-13.—Sample work request.

the input is cards, and the output is magnetic tape plus a listing. The programmer should submit to production control his input material along with the following forms.

Figure 7-14 illustrates a production and operator record (queue slip) for project number 9059060. Notice all filled in areas, except numerals, are completed by the programmer. The areas filled in represent the project number, classification, date, and the programmer's name, initials, and location.

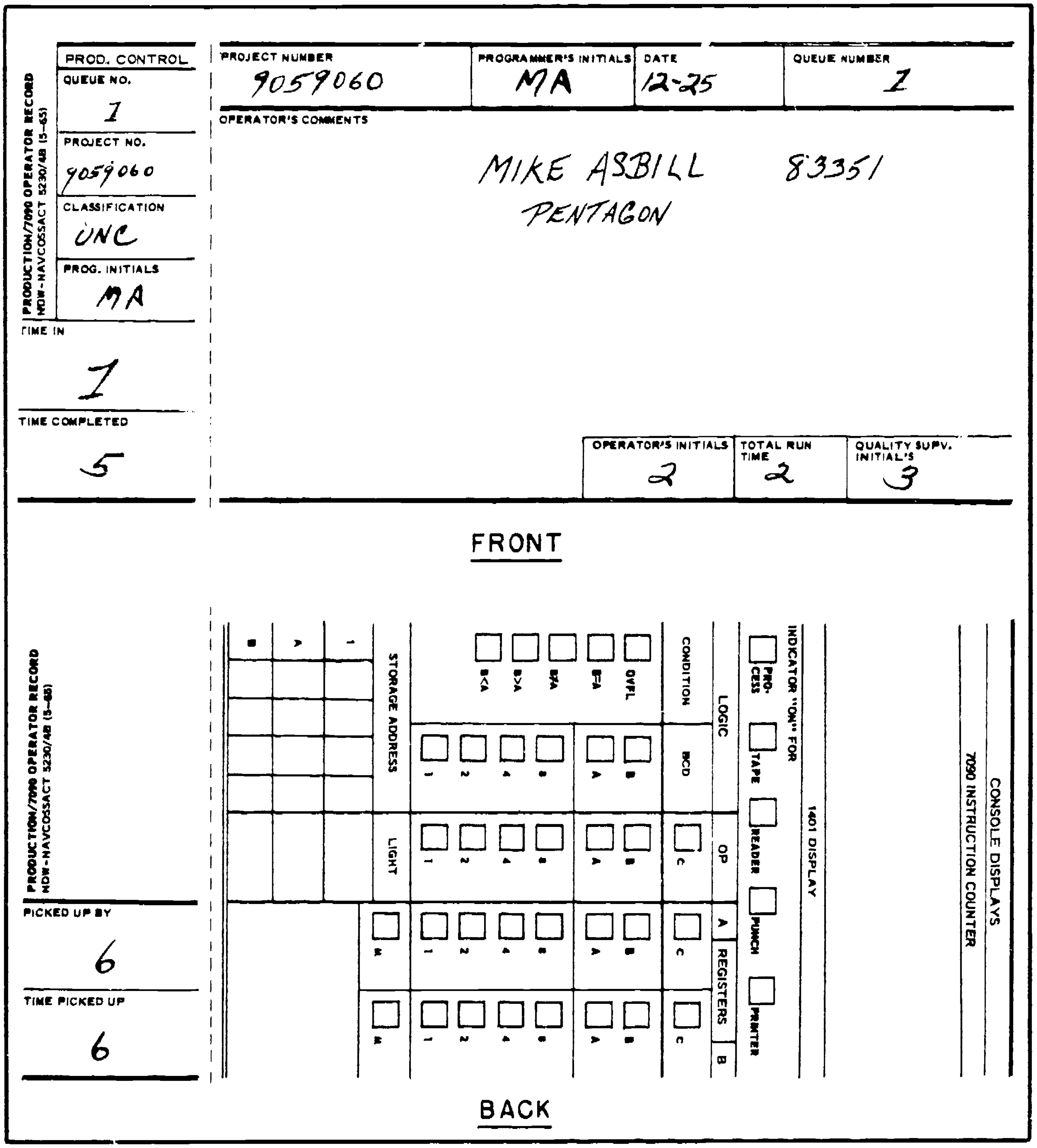
Figure 7-15 illustrates a sample run request. Here again, all filled in areas are completed by the programmer. These include:

- Program name
- Project number or job code
- Operation to be performed
- System to be used
- Classification
- Programmer's initials and phone number
- Estimated running time
- Type of run
- Type of input
- Input/output units
- Density
- Destination

Figure 7-16 illustrates a sample tape library control record for project number 9059060. Both part I and part II are filled in by the programmer (with the exception of the numerals 1, 2, and 4). This form includes:

- Project number
- Classification
- Programmer's name and initials
- Date
- Operator instructions
- Program name
- Program save period

When control receives a request for processing, a commitment is implied. Production



PRODUCTION/7090 OPERATOR RECORD
NDW-NAVCOSSACT 5230/48 (5-65)

PROD. CONTROL
QUEUE NO. 1
PROJECT NO. 9059060
CLASSIFICATION UNC
PROG. INITIALS MA
TIME IN 1
TIME COMPLETED 5

PROJECT NUMBER	PROGRAMMER'S INITIALS	DATE	QUEUE NUMBER
9059060	MA	12-25	1

OPERATOR'S COMMENTS

MIKE ASBILL 83351
PENTAGON

OPERATOR'S INITIALS	TOTAL RUN TIME	QUALITY SUPV. INITIAL'S
2	2	3

FRONT

PRODUCTION/7090 OPERATOR RECORD
NDW-NAVCOSSACT 5230/48 (5-65)

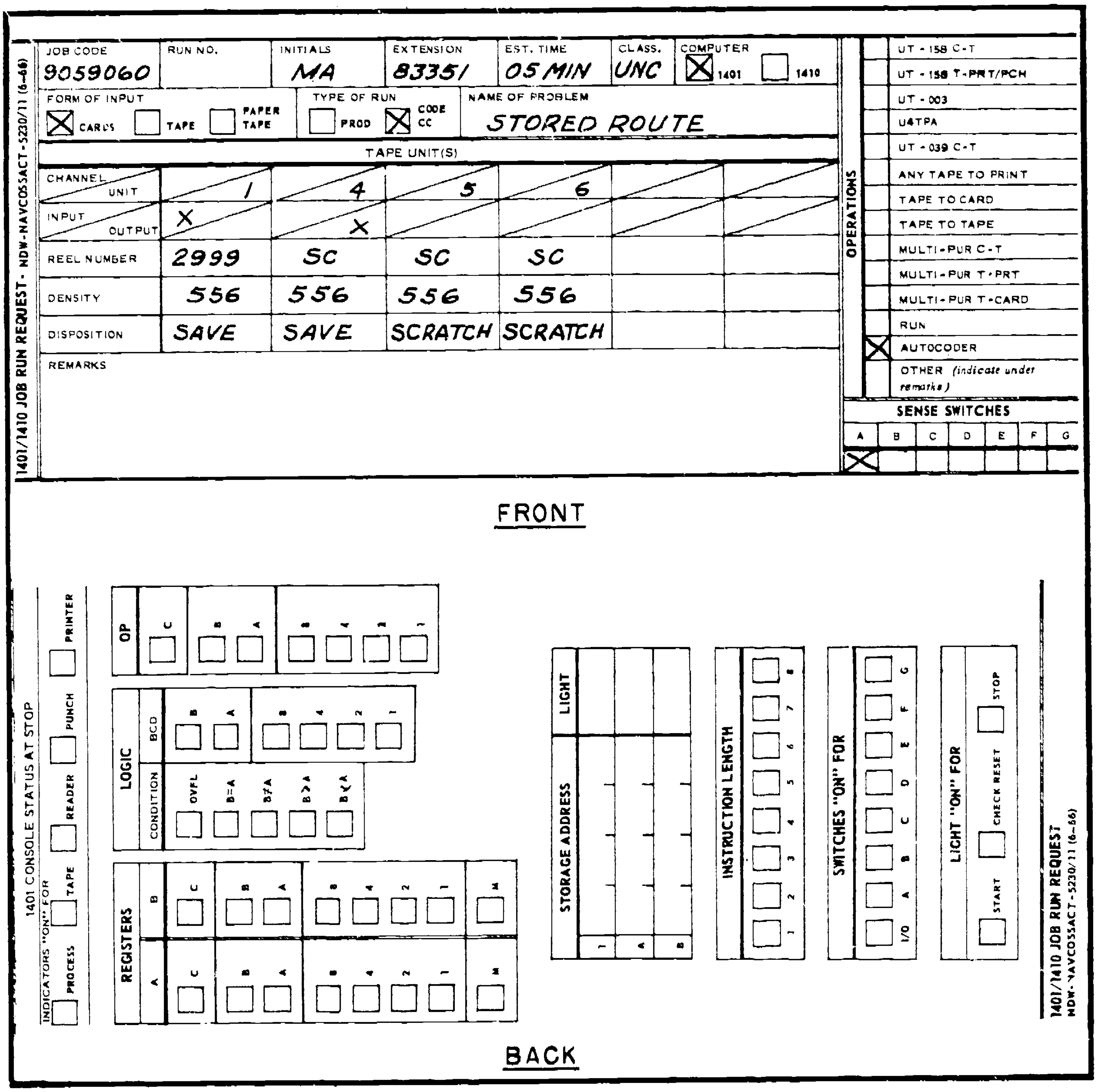
PICKED UP BY 6
TIME PICKED UP 6

STORAGE ADDRESS
LIGHT
CONDITION
B<A B>A B≠A B=A OVFL
BCD
OP
A REGISTERS B
LOGIC
INDICATOR "ON" FOR
PRO-CESS TAPE READER PUNCH PRINTER
1401 DISPLAY
7090 INSTRUCTION COUNTER
CONSOLE DISPLAYS

BACK

78.86

Figure 7-14.—Sample production/operator record.



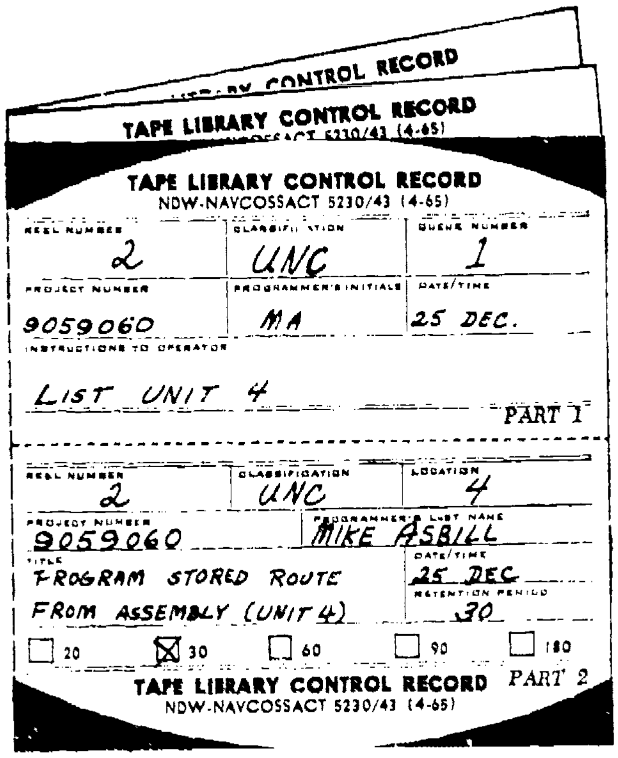
78.87

Figure 7-15.—Sample run request.

control will see that the run is completed in a timely fashion on the basis of the run request. The control personnel have the responsibility of logging in and out all program runs. Maintaining a current listing of all programmers' initials for identification, performing the required preprocessing to ensure that:

- The required forms are completed according to instructions.
- The required materials called for are available.

In some cases the user may furnish, with the request, all material needed for the run.



78.88

Figure 7-16.—Sample tape library control record.

such as card decks, tapes, and forms. However, in naval operating systems, supplies are normally furnished by the installation.

The areas represented by the numeral 1 in figures 7-14, 15, and 16 are filled in by control personnel. The queue number could be any combination of numbers or letters, but is normally arranged by an installation to indicate specific requirements. For example, the first digit, of a 5-digit queue number, could indicate a particular system and/or job priority. The additional 4 digits, in this case, could represent the sequential receipt of jobs. These sequential serial numbers could be renewed each day if desired.

In order to maintain a check over all jobs received for processing, each sequential run number assigned should be entered into a sequential log or, in the case of project 9059060, the stub on the queue form (fig. 7-14) could be detached and kept on file until the run is complete. Once the job is completed, they could be pulled and the file would show how many and which jobs are in process.

Once the required checking by the control personnel has been completed, the application is then delivered to the appropriate computer floor to be run. This may, in this case, be an assembly routine or it may go to a main processor for a regular production run. The operator responsible for the run fills in all spaces of figures 7-14, 15, and 16 indicated by the numeral 2 plus the console display in case of halts due to error conditions. The console display is indicated on the reverse side of the run request and queue slip figures 7-14 and 15.

As soon as the run is completed, it is checked by the quality control supervisor (to be discussed later) and, in the case of save tape situation, by the tape librarian. Upon receipt, the tape librarian indicates the location of the tape on the tape library control record (see numeral 4, fig. 7-16) and affixes part II of the tape library control record to the tape reel for identification. Then the program and all associated material are returned to the control office where checks are performed on all material connected with the run in accordance with given instructions. These checks could refer to various processing steps as well as the physical condition of the output. The job queue slip is stamped with the completion time (see numeral 5, fig. 7-14). Then the programmer is notified that his run is complete.

When the job is picked up, the queue slip is again time stamped and initialed by the programmer (see numeral 6, fig. 7-14). At this time the queue slip stubs may be removed from the file and disposed of or retained as a record.

The forms used may be color coded, if desired, to indicate the classification of applications. For example, red could signify Confidential, green Secret, et cetera.

QUALITY CONTROL

Quality control may be implemented in the control office or on the computer floor. Most often the quality control personnel are part of production control. In this case, however, there is a quality control supervisor on the computer floor for each specific system. The quality control supervisor receives the program and associated input/output from the operator. The quality control supervisor thoroughly checks all related material. Several questions could arise concerning these checks. For instance, in the case of a requested core dump, was it accomplished? In the case of an error stop or unsuccessful run has the console image been recorded? Was the correct type of paper used? Was the request for decollating and bursting accomplished? Was the correct number of copies produced?

Once the quality control supervisor is satisfied that the run is correct, he initials the queue slip (see numeral 3, fig. 7-14) and forwards the completed application to the tape librarian or control office.

MAGNETIC TAPE LIBRARY

Adequate procedures and controls for operating a tape library must be established and maintained if efficient and maximum usage of magnetic tapes is to be realized. Magnetic tape library controls may be set up in many different ways, so long as they provide for adequate identification and control of all tape reels in the possession of the ADP installation.

The reel number is the easiest and most straightforward basis for storage and retrieval of tapes. Any number of elaborate systems can be designed to control and keep records on the status of all tapes. Perhaps the basis for any tape library system will be determined by the total volume of the required tapes.

The tape library may contain relatively few reels of magnetic tapes or it may contain several thousand. In any case, these reels contain vital information. For this reason a rigorous control system must be maintained on the filing and status of these tapes. Tape library controls should provide for the following:

- The physical location of any given file (or one or more reels) should be available from the library records at all times.
- Reels of tape should always be stored in the same locations in the library, as determined by the reel serial number or, alternatively, by file number.
- If a file or reel is absent from the library, the name of the person who has it should be recorded.
- Accurate information should be maintained regarding tapes for which scratch dates have expired, thereby making them available for further use.
- Library records should be concise, and easily understood, and should require a minimum of entries.

PROGRAM LIBRARY

In addition to magnetic tape files it is important that an operating installation maintain effective control of its PROGRAM LIBRARY. A program library will contain such things as program card decks (both original programming cards and machine language cards), program master tapes, utility programs, subroutines, control panels, printer carriage control tapes, etc. An organized procedure for controlling these items requires that each one be clearly marked for identification purposes and that it be stored in a specified place. Over and above this the checking of these items into and out of the library must be carefully monitored. Library records should indicate "when issued" and "to whom issued."

Programs are usually maintained on magnetic tape. It is desirable, however, to maintain a duplicate set in card form. When this is done it is important that the decks remain intact and complete. No changes should be made to them without proper approval and documentation.

There are certain definite advantages to maintaining programs on tape for operating purposes. In the first place an online card reader will not be required. Second, the risk of losing cards is eliminated. In addition, and perhaps most important, loading programs from tape is very much faster than from cards.

Operating with programs on tape does raise certain additional problems. It will, for example, be necessary for a utility routine to locate the desired program on the tape for loading. (The console operator would key in the run number and a search program would locate and load the program into the system.) It will also be necessary to have a maintenance routine for adding, deleting, or changing programs on the tape.

In addition, a tape drive will be needed for the program tape during the loading of a program. This tape drive, however, can often be an alternate output drive for one of the program's output files. There will be time to change the tape reel before the program requires the drive.

In designing a program tape master file, the following matters should be considered:

- The tape may be made up of individual 80-column card records placed on tape in an auxiliary card-to-tape operation. Alternatively, the tape may consist of large blocks of machine instructions that must be placed on tape during a computer run. The fact that programs take less space on tape by the latter arrangement also makes program loading faster.

- The sequence of programs on tape affects the search time that will be required before they can be loaded. Ideally, the programs would be in proper sequence for a day's operation. Often a separate tape is maintained for the various programs required in one application or those required for a particular processing cycle. Sometimes the program may be loaded from the beginning of the first reel of a master file.
- Sorts and utility routines can be carried on a separate tape.
- Duplicate program tapes should be kept in the tape library in the event of damage to a program tape.

Sort programs and other utility programs should be controlled and maintained in the same manner as other programs. Where a standard sort is frequently used, the control (parameter) cards for each sort run must be clearly identified and filed in a specified place. Sort programs that have been modified should be maintained separately.

UTILITY PROGRAMS.—Utility programs are generally small programs that perform such jobs as:

- Creating a tape file from cards
- Creating punched cards from a tape file
- Printing out the contents of storage
- Duplicating a tape
- Consolidating various tape files into one tape file
- Clearing storage
- Loading programs
- System "housekeeping," such as rewinding all tapes, etc.
- Loading or unloading disk storage

It is often desirable to maintain a set of utility programs in a card file near the console. Some of these programs will be used frequently. Sometimes the need for one or another of them will arise unexpectedly. The console operators must of course have complete knowledge of the use and operation of these utility programs.

SUBROUTINES.—In addition to utility routines the program library will also contain a set of subroutines. These are routines that are common to many different programs and are therefore incorporated as elements of these programs. These routines are for such things as:

- Tape reading and writing
- Tape error correction
- Checkpoint—restart
- Tape labeling, etc.

In addition to such "universal" routines there will probably be routines that are unique to the applications of a given installation and which can be used in a number of programs.

CHAPTER 8

DATA PROCESSING MANAGEMENT

The data processing manager is responsible for carrying out the objectives set forth by management. He must have the authority to accomplish his responsibilities and must have the complete cooperation of all levels of management in performing his duties. In accomplishing the objectives set forth, he must keep management informed of progress made as well as any problems which may arise.

Although the procedures for ADP equipment vary according to the purpose for which equipment is to be used, problems of management are quite similar among all ADP installations. No Navy activity using ADP is relieved from the task of applying the most economical contract terms, assuring proper computation of rental and maintenance costs, accurate recording of time, obtaining the most effective use of equipment and all the other aspects of good management.

The concept of ADP management and equipment utilization for command, control and support systems is basically the same as that for multi-functional application operations, although the operating nature of each differs somewhat. ADP equipment for command, control and support systems is generally required to provide information rapidly for making operational decisions. Equipment used for multi-functional and/or management support applications process data on a scheduled basis for effectiveness and economy. Because of improved capability of ADP systems to process data routinely subject to automatic interrupt for high priority processing, the same equipment system can usually be used for management supporting and operational supporting. Full and economical use of Navy ADP systems should be exploited regardless of principal purpose of applications when such use is operationally and economically feasible.

Regardless of differences in required responsiveness, management procedures are fundamentally similar for all ADP equipment in that they will involve:

- Establishing a production control or scheduling system to facilitate the smooth flow of data and to enable the optimum use of equipment and manpower.
- Program maintenance to make relatively minor changes in operating programs to update them, solve program-operating problems, adapt to scheduling changes and correct errors in programs after they have gone into operating status.
- Maintenance of up-to-date documentation of all current applications to ensure efficient control and operation of the installation.
- Recording machine utilization time to provide a basis for computing charges (rental and/or maintenance) and utilization rates for management purposes.
- Establishing inspection and maintenance procedures.
- Developing procedures for the care and control of magnetic tapes.
- Monitoring the availability of punch cards, magnetic tape, tabulating paper and other supplies.
- Ensuring compliance with security directives regarding the handling of classified information.
- Analyzing ADP installation operations continuously to determine areas of low effectiveness and efficiency and then correcting the discrepancies.
- Control of personnel by measuring work performed against either historical data or developed standards.
- Continuous review of records, procedures, and operational effectiveness of all data processing locations at an installation, including physical inspection.
- Continual training of new personnel and updating the training of older personnel.

LIAISON.—The unusual position of the data processing activity within the larger organization—half service, half operating—greatly heightens the importance of the liaison function at the management level. The ADP manager is faced with particularly difficult relationships: he often shares in making decisions that do not relate directly to his own department, and acts as an intermediary with other departments. The problem of translating technical information into management terms is always with him. Finally, in day-to-day operations, he must act to assure a smooth, timely flow of data.

OPERATING PROCEDURES

Operating procedures vary from installation to installation. It cannot be expected that a system using EAM equipment would or could use the same operating procedures as a small EDP system. There are normally different operating procedures for small EDP systems and large EDP systems. For that matter, operating procedures can and do vary between large EDP systems. In every operating system, decisions must be made as to the type of controls and operations. Open and closed shops are discussed in the following paragraphs.

OPEN SHOP

Data processing installations operating under the rule of open shop charge the programmer with the responsibility of performing all functions encountered from the inception to the completion of a given program. Included are:

- Loading all input units with cards, tapes, et cetera
- Operating the console
- Unloading all output units of reports, cards, tapes, et cetera

There is one major disadvantage in the operations of an open shop. For instance, if the programmer had just finished writing a program and had it on the computer for the first time, the chances are that the program will contain errors, and it is only natural for him to try to debug the program while it is on the machine. However, this should not be attempted, because a DP system is expensive, and the time is valuable and must be utilized to the utmost.

CLOSED SHOP

Data processing installations operating under the rule of closed shop never expect the programmer to perform any operating functions. As a matter of fact, it is desired that the programmer not be allowed on the computer floor. If programmers were allowed on the computer floor there would surely be friction between the computer operators and programmers. In a closed shop the operators, under the control of the senior in charge, or designated section, perform all operating functions and should not be interfered with by unauthorized individuals. An unorganized installation creates undue hardship on both operating and management personnel.

COMBINATION OPEN/CLOSED SHOP

There is a commonly used variation between open and closed shop operations. In certain cases it is important for program development personnel to attend the running of development programs and/or for program test and integration purposes. However, this should only be allowed upon request and where their presence is required to complete the run. Although it is not recommended practice, in some cases, installations do allow programmers to be on the computer floor while their programs are being run, but they are not allowed to participate in the actual operation of the equipment.

SCHEDULING

Scheduling is one of the most important and difficult jobs of an operating installation. Schedules should be tight enough to preserve valuable machine time; yet flexible enough to allow for setup time, manual operations in case of errors, and unavoidable delays. Scheduling requirements will generally be determined by the characteristics of an installation. The following cases present two extremes:

1. An installation that operates within rigidly prescribed standard application.
2. An organization that provides service for a multitude of users.

Most installations fall somewhere between these extremes and the scheduling must be tailored to meet the needs of the particular installation. Operating under rigidly prescribed standard applications normally ensures a relatively fast turn around. Whereas, with a multitude of users the turnaround time depends on the total workload, and the distribution of this workload. To do an effective job of scheduling, the schedule must be realistic. A realistic schedule allows for buffer periods. The basic reason for buffer time comes from the fact that a data processing run involves the coordination in time of several activities. Perfect coordination of all activities cannot be expected.

The value of scheduling specific time for program testing has been proven by experience. A continuing need for test time is evidenced by the development of new applications, and maintenance and improvement of existing programs.

To keep setup time to a minimum, optimum scheduling must be employed. Also useful in minimizing setup time is intelligent programming which keeps to a minimum the number of changes of tape reels.

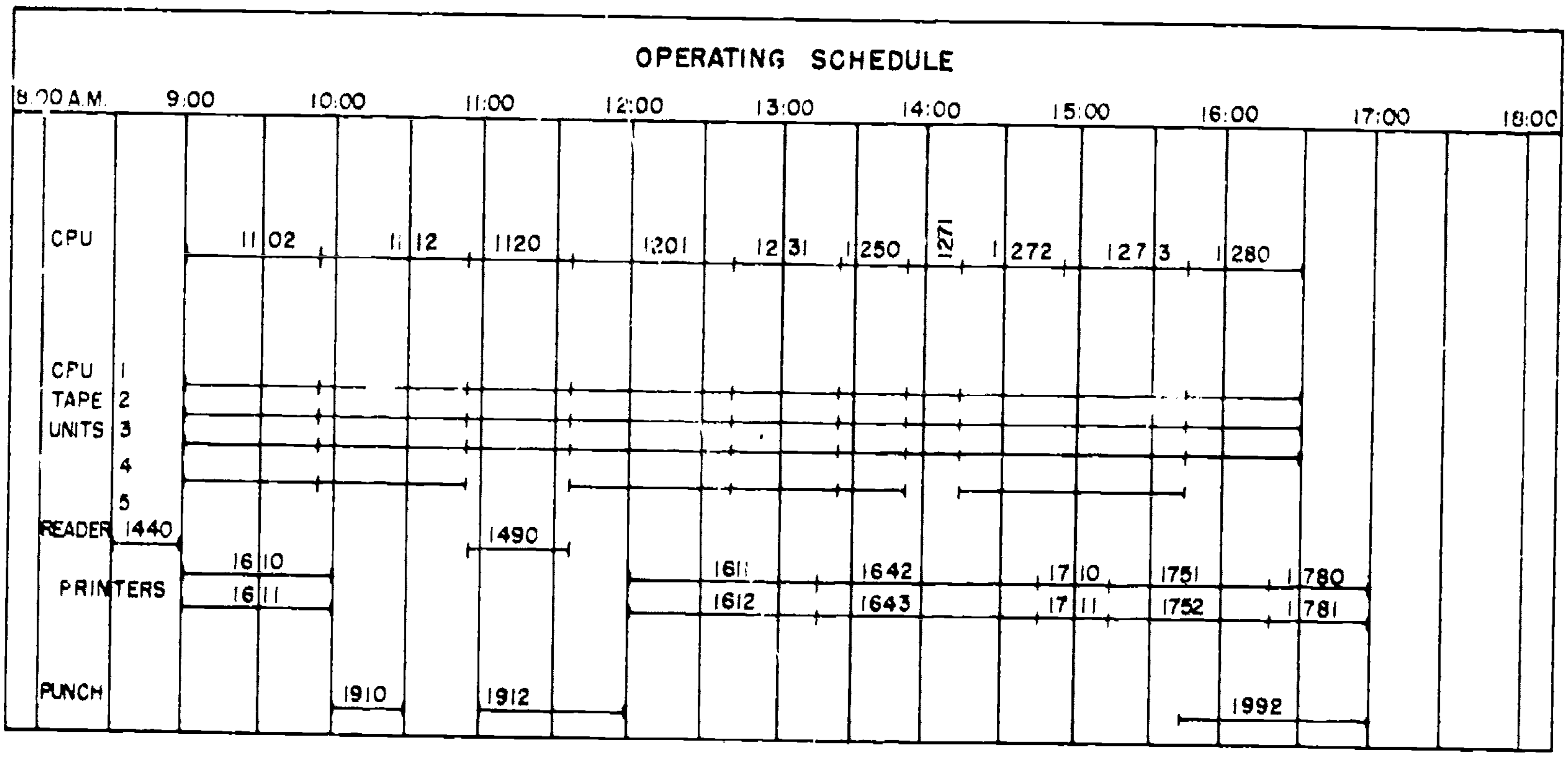
A typical example of an operating schedule is shown in figure 8-1. This schedule shows time across the top and auxiliary and system components down the left margin. The solid horizontal lines indicate the time that each unit is in use. The numbers above the lines indicate the run number for which the unit is being used. This example shows that 5 tape units are available and that 3 and sometimes 4 are being used in these runs. The auxiliary operations, tape to cards, cards to tape, and tape to printer, are performed when the main system is not using the number 4 and 5 tape units. The printer, reader and/or punch could also be used on line.

In addition to scheduling testing time, all production runs must be scheduled to ensure utilization of the equipment. In the case of standard runs, they should not exceed certain set limits on input/output (I/O) and running time. The practicability of reasonable limits can only be determined through a study of the systems environment. For instance, do all applications utilize all alloted I/O time? The norm usually reveals that I/O time just about doubles that of the processor.

Special, nonstandard, runs that exceed the set time limits for standard runs usually are run at night in a busy installation. In the case of often expected longer runs, it might be feasible to have a monitor with an automatic interrupt feature. With this system the computer can alternate between standard and special runs. Some time may be lost, each time an interrupt is required because appropriate storage of all conditions within the main processor is required at the time of the interrupt. But this loss is normally insignificant compared to the improvement in the overall computer utilization.

SCHEDULING OPERATIONS

Scheduling operations cannot be a hit or miss proposition. Machine utilization at all times should accord with a predetermined schedule. The schedule should give the operating group



78.84

Figure 8-1.—Typical operating schedule.

either a specific listing of jobs to be done, or a specific timetable of the sequence in which jobs should be processed. Input data availability and all demands for machine time must be coordinated and reflected in the schedule. The schedule must make provision for:

- Regular production runs
- Special requests
- Program testing and assembly
- Unscheduled maintenance
- Rerun time

Scheduling can be considered as the act of screening all requests for machine time and allocating time on the basis of:

- Optimizing machine usage
- Meeting all prearranged commitments
- Reducing idle machine time
- Minimizing personnel overtime
- Designating sufficient time for contingencies

There are several ways of establishing an effective schedule. Basically, the scheduling operation is spread out over a time period. Repetitive requirements may be planned as soon as they are known. For example, if a specific report is to be prepared on a specific date and the time requirement is 2 hours, this can be planned because the requirement will remain static for as long as the job exists. Further, the approximate time of day can be specified according to availability of input data or need for output data.

A preliminary schedule should be devised on a monthly basis and should include recurring jobs. In developing this schedule, an examination of the following factors will provide enough information to outline operations throughout the month with some degree of accuracy:

- Is this a repetitive run or a one-time request? If it is repetitive, is it permanent or temporary?
- Does the volume of data vary from one run to the next?
- Does the production time take into consideration setup time?
- Is the availability of the input data always on time or is it often late and incomplete?
- Do the input data require extensive setup time?
- Are there occurrences of poor data preparation or invalid controls?
- What are the number and type of data errors and exceptions encountered?
- What is the relationship of one application to another—can the setup functions be consolidated to facilitate setup time?

There are many things which will cause a variation in setup time. For example, individual operators, the number of manual interventions required for a given program, and the mode of operation at the data processing center. Historical data that will aid in making reasonable estimates of setup time can be accumulated.

Estimates of program running time should be included with requests for machine time. The programmer can determine this estimate when he is in the final stages of testing the program. An example of a machine time request form is shown in figure 8-2. Note that the entry

REQUEST FOR:

☐ ASSEMBLY
☐ TEST
☐ PROCESSING
☐ OTHER

JOB NO. ____________

DATE ____________

REQUESTED BY: ____________

UNITS REQUIRED

☐ CPU
☐ MFCM
☐ RDR
☐ PCH
☐ RDR-PCH
☐ PRT
☐ OTHER

ESTIMATED RUNNING TIME ____________
SETUP TIME ____________
ERROR RECOVERY ____________
COMMENTS:

78.76X

Figure 8-2.—Job Request.

"estimated running time" does not include setup time or provision for error recovery. These should be estimated by the scheduler and added to the programmer's time estimate.

The following questions must be answered for each installation before scheduling procedures can be established:

- Who determines the priority and sequence of processing and issues schedule commitments?
- To whom are requests for machine time made?
- From whom do machine operators receive final machine schedules that indicate actual job processing sequence?

The answers may differ greatly among installations, depending on the nature of the processing done, size of the installation, organization of management, and the extent of computer operation.

Several scheduling techniques may be applied during the scheduling period to determine final sequence of processing. They are summarized below:

Priority System.—For many reasons, one program can take precedence over another. It may be determined, for example, that all requests from the supply department will receive immediate attention, ahead of the requests from other departments. It may be that priority is dictated by the processing sequence of an application, or priority may have to be decided on the basis of a subjective evaluation.

Normal Frequency.—Regularly scheduled (that is, repetitive) jobs may take precedence over all others. In some cases repetitive work may not be required on a specific date and can be processed within a specified range of time.

Demand.—Jobs may be accepted and processed in strict chronological sequence, as requests for processing time are received.

Combination of the Above.—In most installations, actual scheduling is a combination of all the above techniques.

When scheduling machine time and when reviewing machine utilization, distinction must be made between different categories of time. This is of value for analysis, and for projections of machine requirements. If machine utilization analysis is done manually, forms used for scheduling machine time should have room for actual time to be posted after the fact. The form illustrated in figure 8-3 can be useful in this respect. However, the layout is not an important consideration as long as there is provision for the following categories of time:

- Production time—time used for processing an application.
- Assembly time—time used for program assembly or compilation.
- Testing time—time used for program testing, whether used by operations or programming.
- Training time—time used for training operation or programming personnel.
- Preventive maintenance—regularly scheduled time when the machine is to be made available for maintenance.
- Unscheduled maintenance or downtime—any time that computing equipment is under maintenance that has not been scheduled.

DAILY LOG

RUN NUMBER	DEPT	TIME											ERRORS		COMPONENTS USED							REMARKS
		ON	OFF	PRODUCTION	ASSEMBLY	TESTING	TRAINING	PM	DOWN	RERUN	BUFFER	OTHER	MACHINE	USER	CPU	RDR	PCH	PRT.	MFCM	RDR-PCH	OTHER	

78.77X

Figure 8-3.—Daily Log.

- Rerun time—required because of either operator error, data error, machine malfunction, or faulty input or output media. Whenever a job must be reprocessed, the reason should be indicated.
- Buffer time—idle time allowed to give some schedule protection for unpredictable events during processing.

Run Scheduling

Use of the run scheduling method permits estimating the completion time of any run assuring the user when delivery can be met. For each individual operation, the setup time, start time, and completion time must be specified. Under this method it is necessary to develop a program for setting accurate time standards and an adequate internal communications system. For each run the following minimum information is required:

- Availability of input data
- Volume or number of items handled or produced
- Identification of computer or work center assigned to do the operation
- Time necessary to set up each required operation
- Required running time for job
- Knowledge of the exact status of the run and its inputs and outputs as it relates to other runs

Scheduling by Shift

By this method periods of time are allocated for various processing such as production, test, compile, and maintenance. Instead of attempting to do detailed planning normally associated with run scheduling, each application is assigned to a specific shift or portion of the shift. No attempt is made to specify when, within the time period, the processing is to be started. At the beginning of each time period, each facility is provided a list of runs that must be completed during the period. It becomes the responsibility of the section supervisor to determine the best sequence for doing the processing, etc. In short, the supervisor is responsible for the detailed scheduling within a shift.

PRODUCTION CONTROL AND SCHEDULING

In discussing scheduling, it becomes apparent that some of the production control functions are highly interrelated with scheduling computer operations. For instance, realistic scheduling is quite dependent on routing of work. Dispatching of work is dependent on planning and reporting. However, whatever technique is used, a good production control and scheduling system can reduce cost and be responsive to the user. As computer time runs at a fixed rate of speed the techniques to get the work done faster generally involve new setup, scheduling, and handling techniques. A portion of the usable time of an ADP system is consumed by assembly, compiling, program checkout, sort, or other get-ready work to keep it running smoothly. It is this get-ready phase where a fertile area exists for cutting costs through better scheduling and handling.

WORK LOADS AND TIME FACTORS

Determining work loads and establishing time factors for performing various jobs are essential elements in the efficient management of an ADP installation. They lend assistance in maintaining a realistic operating schedule, establishing standards of performance, and in compiling cost figures for jobs performed.

Proper control over workloads entails keeping records of the actual quantity of documents, materials, and reports, and how the quantity fluctuates from time to time. These records provide valuable assistance when applying time factors to operations.

Data processing essentially includes clerical, key-driven, and automatic operations. The time required for operations of a clerical nature must be determined by experience, test, or estimate, or a combination of these factors. The time required for key-driven operations may be determined from production records of previous operations, taking into consideration such factors as the experience of operators, the design and complexity of source documents, and the physical environment. The time required for automatic operations is determined by a more scientific approach, using your own knowledge of rated machine speeds, setup time required, and the amount of handling time involved. The combined time for clerical, key-driven, and automatic operations required in the performance of a given job yields the total time required for that job.

MEASURING WORK VOLUME

Information concerning the volume of work encountered must be available before realistic time factors can be assigned to each operation in all regularly scheduled jobs. It is essential to have accurate knowledge of the number and types of source documents received, number and types of cards punched and processed, and the number and types of reports produced. Insufficient knowledge of these facts often causes deficiencies in scheduling. Many supervisors complain that fluctuating or unexpected workloads create difficulty in maintaining schedules; such situations warrant a close analysis of workloads.

There are several ways in which information about the number of source documents can be obtained, depending upon the particular type of document controls established. In some cases item counts and number of batches are recorded as part of the document control routine. In other cases the actual number of documents received may be counted and posted to a control ledger. When gathering information about the volume of source documents, a good sampling period should be selected, corresponding as closely as possible to average conditions. The maximum and minimum volumes expected within this time period, and when they will occur, should be established.

Card volumes are another important item to compile figures on. There is a twofold reason for having an accurate record on card volumes:

1. They have a direct bearing on determining the best method for accomplishing a job.
2. They are applicable to machine workloads for the low, average, and peak periods of the month.

The time required, particularly for EAM operations, is dependent primarily upon the number of cards involved, and the number of times the cards must be run through a given machine. Fairly accurate card counts can be obtained when cards are punched, provided the card punching section maintains production records.

Another volume figure affecting the assignment of time factors is the net output of the installation. A count of the number of pages produced in all reports and documents over a period of time generally will indicate the expected output volume. These counts may be obtained automatically during report preparation, or by manual tabulations as each report is completed.

DETERMINING TIME FACTORS

Any function performed in a data processing installation can be classed as one of three types; clerical, key-driven, or automatic. Some jobs may be performed solely through the utilization of only one type of function; other jobs may require either two or all three types. Different methods must be employed for determining time factors applicable to each type of function.

Clerical Operations

Clerical operations are extremely difficult to plan or schedule, since human variables and individual job peculiarities are present to a great extent. One basis for determining clerical time factors is by reference to statistical analysis and efficiency records pertaining to standard clerical functions performed in the installation. In some cases time factors from a similar operation can be used, provided the clerical routines in both operations closely parallel each other. A more realistic approach is to establish a carefully selected and controlled test period using samples of the actual work. Clerical operations commonly are tried out before any definite plans or schedules are prepared, simply because the human variables involved and the errors encountered in educated guesses preclude the use of any other method.

Key-Driven Operations

Time factors for key driven operations are more easily established than for clerical operations because the production rate of an operator usually is known. The efficiency and accuracy of key-driven operations are affected by many different factors, each of which should be given careful consideration in determining time factors, evaluating work performed, planning new procedures, or improving existing procedures. A resume of these factors, including applicable considerations, is presented as follows:

- Document and card design.—The design of source documents and card forms is an important factor in attaining speed and accuracy of card punching. The best design provides for exactly the same arrangement of items on both the documents and the cards. The ideal source document for card punching has all information which is to be punched in one card recorded on one line, arranged so that reading and punching can be performed from left to right. Card punching speed and efficiency are affected further by the design of the card with respect to fields which are to be punched, duplicated, or skipped. Best operation is realized when duplicated information appears at the left of the card, and when all manually punched fields are grouped together so that punching need not be interrupted by skipping.

• Legibility of source documents.—One of the most important factors that affect production in card punching is the degree of legibility of source data. When multiple copies of source documents are prepared, the keypunch section should be given the original if possible; otherwise they should be furnished the clearest carbon copy available. Source documents which require manually recorded data should be designed to provide enough space for writing large, legible characters.

• Number of columns punched.—The number of columns to be punched per card has a direct bearing on the number of cards punched per hour. When evaluating production of card punch operators, it is customary to express production in terms of columns punched, or key depressions, per hour. The number of cards punched per hour multiplied by the average number of key strokes per card yields the gross hourly production.

• Skill and experience of operators.—The training and experience of operators must be considered when determining time factors for key-driven operations. For new operators, it is important to know how much improvement they are making rather than their production record or number of errors made. An absolute proficiency evaluation can be made only after an operator has reached a level rate of production.

• Type of equipment used.—Changes in the type of key driven equipment used, and the installation of time-saving devices, may affect the production rate of operators. For example, the use of an alternate program device should be considered if two types of cards requiring two separate program controls are to be punched from the same source document. An alternate program device eliminates the necessity of handling the source documents twice.

• Instructions to operators.—Clear and complete instructions contribute toward increased production and error reduction. Written instructions are preferable, since verbal instructions may be misinterpreted or lost in the shuffle. Complete documentation of all instructions for key driven operations should be included as a part of the operator's manual of procedure.

• Volume of transactions.—Operators who prefer routine work usually have a higher production rate when working on large volumes of source documents which require no change in machine setup, documents, or cards. Conversely, operators who prefer change and novelty will become fatigued quickly when they are faced with the prospect of performing unchanging, repetitive operations on a mass of documents. Individual temperaments should be considered when weighing the element of fatigue against the volume of transactions.

• Flow of work.—Decrease in production results when an operator is interrupted continually to perform special jobs, when a job is shifted between operators, or when work is done sporadically as documents become available. If more than one operator is required for a job, the work should be equally distributed to all operators concerned, in accordance with their productive capabilities.

• Duties other than card punching.—Assigning other duties to card punch operators such as coding, auditing, and operating automatic equipment, inevitably lowers their card punching production rate. On the other hand, variety may contribute to higher morale and reduce the fatigue factor. It is necessary to strike a balance between continual card punching and other duties so that a desirable production rate can be maintained without placing undue hardships on the operators.

• Working conditions and morale.—The production rate of card punch operators is affected to a considerable degree by the factors of working conditions and morale. These are intangible factors which too often are overlooked by supervisors. The comfort of operators should be considered by providing a room in which the temperature, humidity, and ventilation are controlled properly. Extraneous noises should be kept to a minimum. Coffee breaks, or rest periods, should be provided at regular intervals to reduce the fatigue factor.

Automatic Operations

The determination of time requirements is dependent primarily upon the type of machines used and the type of operations performed. Basically three factors must be considered in computing time requirements for completion of a job:

- Setup time.—The first element of operation time is setup time. Setup time includes mounting tapes, inserting control panels and printer forms, bringing input media to the machine, making necessary switch settings and adjustments, and perhaps receiving instructions pertaining to the operation to be performed. All such operational details, performed prior to actual processing contribute to setup time.
- Machine time.—The second and usually the major element of time is machine time. This is determined by an analysis and segmentation of each application into elements which identify each processing step, the volume and flow of all processing workloads and the type of processing involved for each step, e.g., sorting, collating, summarizing. By first identifying the volume of workloads and comparing them to machine processing capacities, a preliminary estimate of machine requirements can be derived.
- Handling time.—The third element of time applied to an automatic operation is handling time. After the operation begins, it is normal to expect short interruptions in the operation of the machine. These interruptions may be caused by such details as handling I/O data, spot-checking the results of machine operation, checking or balancing results, making minor adjustments to the machine, and handling many other details for good operational control. The amount of handling time involved depends upon the duration of the operation. The longer the operation lasts, the more handling time accumulated. For this reason, handling time is figured as a percentage of machine or total time rather than as a set amount. Realistic determination of handling time can perhaps best be made by analysis and evaluation of previous runs of the job.

EVALUATION AND IMPROVEMENT

An effective ADP installation involves the use of skilled Data Processing Technicians and expensive complex equipment. To employ these resources in an optimum manner demands continuing analysis of the operation. The establishment of good operating procedures and techniques does not necessarily mean that these methods will always be the best for continued operation. Changes in production requirements, workloads, and equipment necessitate continuous review of present procedures in an endeavor to obtain optimum results through a minimum of effort and cost.

All Department of the Navy activities and contractor operations are required by SECNAVINST 10462.7B to report on the equipment utilization and application. Although SECNAVINST 10462.7B specifies the format for these reports, most activities require utilization data for their own use above and beyond what they are required to report.

The collection of operating data, analysis of utilization and performance, and continuous review of existing procedures are factors which can be used for evaluating the effectiveness of existing data processing systems and for improving the original plans.

When practical, results of the analysis can be presented in chart form displaying trends. These should illustrate to the manager the trend of the operations and point out areas which need detailed attention. Other results may be in report form for future guidance. Principal review areas of an installation's operations are:

- Equipment utilization
- Utilization rates
- Benefits
- Equipment capabilities
- Manpower effectiveness
- Maintenance
- Production schedule
- Adherence to the installations approved data processing program

EVALUATION DATA

Analysis of ADP will vary in intensity according to the size of the installation. Larger installations of the multi-computer variety may expend continuous effort along these lines and may devote one or more personnel towards this end.

While time estimates may present a fairly good indication of the time required for a job, actual machine utilization statistics should be kept so that comparisons with the estimates, and adjustments as necessary, can be made. Job requirements, work loads, and operating procedures are subject to change from time to time, and careful evaluation of machine utilization can provide valuable assistance in revising operating schedules necessitated by such changes. Operating data can be obtained from machine utilization sheets and job cards, or other forms used for recording machine and personnel usage facts. Such data can be used for performing several types of evaluations by classifying and summarizing the facts in the desired form.

Various methods may be used for recording machine utilization. In many installations, a time clock is made available near or on the console in order to allow exact clocking in and out of all program runs. A time card should provide for recording such items as which programs are run, when started, when finished, type of operation (production, program test, rerun, etc.), and components used. A sample time utilization card is shown in figure 8-4. Other forms may be devised and used, depending upon the needs of the particular installation.

The advantage of this DUAL CARD method is that it serves as both a source document and processing medium, allowing the manipulation of facts and the preparation of reports to be performed by mechanical means, thus saving considerable clerical effort.

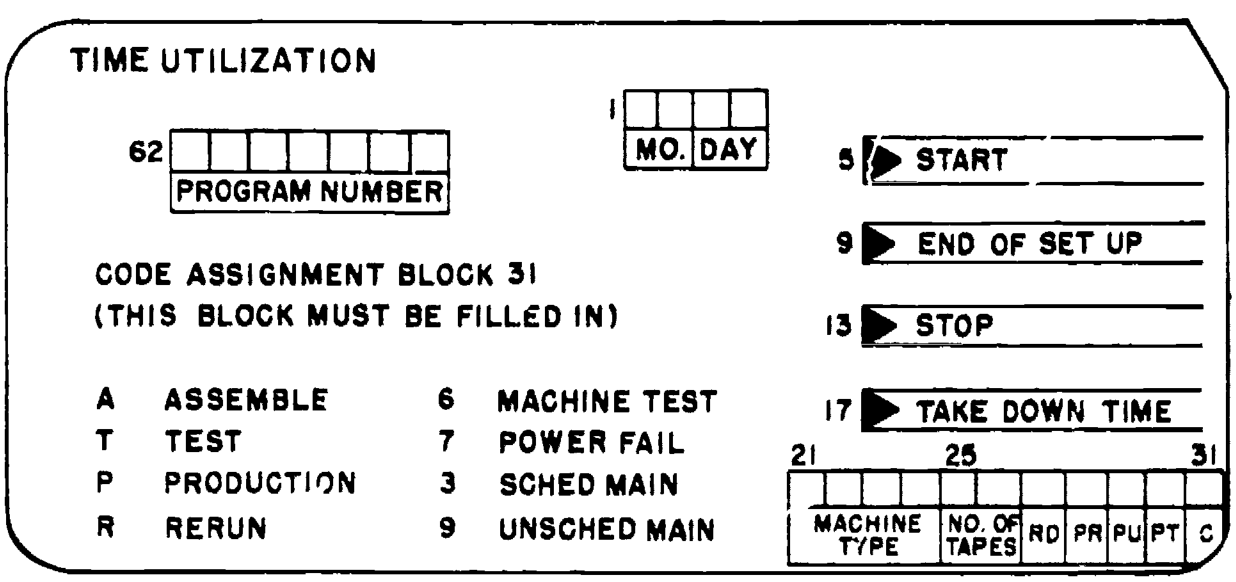
A realistic picture of machine utilization is based on the PERCENTAGE of available time used rather than on the ACTUAL time used. Available time is based on the number of hours included in a normal work shift, minus any machine downtime. The actual time used, divided by the net time available, yields the percentage of machine utilization. Statistics of this sort, when analyzed over a period of time, may indicate a need for revising the operating schedule so that peak workloads can be reduced. They may indicate also the need for procurement of additional equipment or the possibility of re-leasing some of the existing equipment.

Machine utilization statistics can be used to determine the total time required for completion of each data processing job, to show the time during a given period when each job was actually performed, and to indicate the machines used in completing the job. Such statistics will provide for maintaining more rigid and realistic operating schedules, as well as providing the basis for determining time and cost figures for each job. Machine hourly rental rates (or prorated hourly cost rates for purchased equipment) and operator pay rates can be introduced into machine utilization cards through the use of master cards to permit computations of the total cost for each job.

Operating data may be used to a certain extent as an assist in maintaining equitable work distribution among machine operators. It must be kept in mind, however, that machine operation does not, in many cases, represent the total effort required in executing a data processing procedure. Manual steps required for posting and checking control totals, handling exceptions, and performance of other clerical functions increase the total time required for the complete processing routine.

IMPROVEMENT THROUGH EVALUATION

Managers of ADP installations should be on a constant lookout for ways in which to improve the operating efficiency of the installation. Improvements may be made occasionally on the


TIME UTILIZATION
62 PROGRAM NUMBER
1 MO. DAY
5 START
9 END OF SET UP
13 STOP
17 TAKE DOWN TIME
CODE ASSIGNMENT BLOCK 31
(THIS BLOCK MUST BE FILLED IN)
A ASSEMBLE
T TEST
P PRODUCTION
R RERUN
6 MACHINE TEST
7 POWER FAIL
3 SCHED MAIN
9 UNSCHED MAIN
21 25 31
MACHINE TYPE | NO. OF TAPES | RD | PR | PU | PT | C

78.138

Figure 8-4.—Sample time utilization card.

basis of sudden inspirations but, more likely than not, they are the result of careful review and analysis of existing reports, procedures, machine usage, operation, and experience. Cooperation on the part of all personnel concerned, from upper management to data handlers, is essential if improvements most beneficial to an installation are to be realized.

Improvement of Reports.—All reports being produced by a data processing installation should be reviewed periodically to determine if the preparation of each report is justified, and if any changes can be made which will improve their quality. Increases in job requirements often result in the establishment of new reports, some of which may contain information similar to that in reports presently being prepared. It may be possible to consolidate two or more reports into one that will provide recipients with the required information, resulting in substantial savings of time and money within the installation.

Improvement of Procedures.—Changes in report requirements may necessitate establishing new operating procedures or modifying existing procedures. New procedures which are put into effect without first analyzing existing procedures may cause an overlap or duplication of work already being performed. On the other hand, cancellation of job requirements may eliminate some of the job steps in existing procedures. In the interest of realizing the most efficient operation, all operating procedures should be reviewed from time to time to determine whether any changes are required so that procedures may serve the most useful purpose.

Improvement of Machine Usage.—One of the principal objectives of a supervisor should be to achieve maximum utilization of the data processing equipment for which he is assigned control. Maximum value is assured only when such equipment is used productively to the maximum extent possible during a regularly scheduled work shift. A careful analysis of machine utilization over a period of time may reveal several important facts. It may reveal that certain machines are standing idle for several hours each day during the "slack period" but are used extensively for overtime work during a peak period. Machine rental rates generally are based on a stipulated charge for a specified number of hours of operational use time for each machine during a calendar month. Additional charges accrue when equipment is used in excess of the operational use time. In the interest of economy, the operating schedule should be analyzed and revised if possible to provide for more evenly distributed work throughout the rental period, thus reducing peak workloads and the amount of extra use charges.

In some cases an analysis of machine utilization may indicate consistent idle time for certain machines throughout the month. While this may be construed to mean that jobs are being performed in the most efficient manner, it means also that room for improvement still exists if maximum value is to be derived from the equipment. In this case, the supervisor should search for additional work which would produce results of value to the recipient without placing an undue workload on any given machine required for the job.

It is impossible to realize optimum machine utilization if equipment is not kept in good working order. Equipment needs periodic attention, not only for repair of malfunctions but for preventive maintenance as well. The supervisor should work out inspection schedules with the customer engineer, maintain close control over machine performance, and secure the cooperation of machine operators in exercising necessary care in the use of equipment. Just as "an ounce of prevention is worth a pound of cure," so will a small amount of preventive maintenance on the part of operators go a long way toward keeping machines in top working condition. Proper observance of the RULES FOR MACHINES listed in the Rate Training Manual for Data Processing Technician 3 & 2, NavPers 10264-B, is one of the traits of all well-trained machine operators.

Improvement of Operation.—When productive tools are provided for performing jobs better and faster, there is a natural tendency to forget the job the PERSON is doing and to concentrate attention on the job the MACHINE is doing. While data processing equipment may perform many of the detailed, repetitive, and routine functions, the operator still performs important duties which the equipment cannot do. He must exercise the functions of control, analysis, judgment, decision, and evaluation, which remain the most important aspects of a given operation. For example, if you observe closely the operation of an accounting machine, you will note the operator performing functions over and above those of the machine during the course of operation. He selects and moves the proper cards to the machine, joggles them, and places them in the feed hopper. He selects the proper forms and positions them in the carriage. As the work progresses, certain interruptions arise for checking results, making minor machine adjustments, asking questions, and receiving instructions. These are variable factors present to some extent in all operations. The extent to which they apply to a given operation is measured by the operation efficiency; that is, the ratio between running time of the machine and the total time required for the job. Operation efficiency will vary, depending upon the training and experience of the operator and the nature of the job.

As equipment with greater productive potential is brought into use, the THINKING function of the operator increases in importance. To illustrate, consider the difference between an operation performed with an accounting machine and one performed with an electronic data processing system. If an operator using an accounting machine fails to set alteration switches correctly, he may produce a worthless report. When his error is discovered, the only corrective action necessary is to set the switches correctly and re-run the report. If he is using an EDPS however, he may accidentally use master tape reels for a writing operation, and by inserting protective rings can destroy valuable records which may be extremely difficult or impossible to reconstruct.

Past performance records determine the standard operation efficiency which the supervisor uses when assigning time requirements to various jobs and when establishing schedules. It should be the objective of each supervisor to raise this standard gradually and continually. There are a number of ways in which the operating standards of a data processing installation can be raised. Some are listed in the following paragraphs; you may be able to think of others.

- A continuous on-the-job training program should be instituted and maintained for machine operators.
- Manuals of procedure containing accurate operating instructions for all jobs performed should always be available to operators.
- Morale should be kept high by promoting better working conditions, improving administrative relationships, and by being fair and impartial. Above all, supervisors should exhibit those traits which mark a man as being a real leader of people.

Eliminating Overtime

Overtime use of ADP equipment should be eliminated if at all possible. This may be done in a number of ways, depending upon the particular conditions existing in a given installation.

It may be possible in some cases to change the due-out time of certain reports to coincide with a time when machine utilization is not at a premium. Changes of this sort should not be made however without first consulting with the recipient of the report as to possible or probable consequences.

When due-out times cannot be changed, the possibility of changing due-in times for source documents should be considered. Changing the due-in time to a time earlier than originally scheduled may prohibit the inclusion of all documents required for complete coverage of transactions occurring during the normal reporting period. If complete coverage is not an absolute necessity, this method may be used quite effectively.

If neither the due-out nor due-in times can be changed, the peak workload may be reduced by more frequent processing of data files. For example, if the peak workload is caused by the necessity of processing voluminous transactions to a master file before reports from that file can be prepared, the processing function may be divided into several smaller operations spread over the accounting period so that the final processing can be completed in a minimum of time. Summary cards or tapes obtained from these periodic processing cycles may be combined with the detail transactions for the final processing cycle to effect the end result of processing and report preparation.

Use Idle Time Productively

Another method of improvement is to use idle machine time for productive purposes. Some of this idle time may be used in relieving the peak workload period, as indicated above. Other ways of reducing idle time include providing more information on existing reports, preparing additional reports in those areas not previously mechanized, and adding more recordkeeping functions to the machines when it is economical to do so. The economies that can result from mechanizing additional parts of the record-keeping activities of an organization can well justify the cost. When idle machine time is employed for additional work, the cost may be negligible compared with the results.

The use of idle machine time is more easily controlled for EAM applications than it is for EDP systems. Sometimes it may be found that one installation cannot possibly find enough jobs to keep its hardware in full-time operation. In this case, the possibility of sharing the system with another organization should be investigated. In this way, maximum utilization of the system may be realized while at the same time lowering the operating costs for the installation and providing services to additional users.

Improving Scheduling

If possible, the fluctuating workload from day-to-day should be smoothed out to provide for a more constant workload. Such fluctuations usually are the result of poor schedules or the total lack of scheduling. Advance planning may result in different jobs being alternated or staggered so that machines are used for approximately the same number of hours each day. This would provide a more desirable operating situation, with a minimum of machine conflicts. Scheduling is a requisite for this condition.

INSTALLATION MANAGEMENT

The Data Processing Technician in charge of the installation must ensure that his operations conform to the data processing program as approved by higher headquarters. He must conduct reviews to determine that equipment is used for applications for which it was justified, and must also ensure adequate staffing with trained personnel and proper equipment for assuming operational responsibilities according to his installation program.

When and where to apply corrective action should be determined by the installation manager. High programming and operating error rates may indicate programmers and operators are becoming careless. High setup and idle rates may indicate too much time is expended between programs. The aforementioned management tools can show the manager problem areas, but he must initiate the action to rectify them.

The following paragraphs deal with some of the actions necessary to maintain an effective ADP installation.

PERSONNEL EVALUATION

The efficiency of machine operators must be considered when assigning time factors to various jobs and establishing schedules for EAM operations. Likewise, the skill and experience of programmers must be considered when setting a target date for completion of a program for an EDPS. In either case, evaluation generally is based on a comparison of an individual's capabilities against standards established from past performances of skilled personnel.

When evaluating the work of a machine operator, it is important to consider his training and experience. For a new operator, the number of cards processed and the number of errors made are not so important as how much improvement he is making. This trend is the best indication of the type of production that can be expected in the development of each operator. The efficiency of an operator should be measured against established standards only after he has reached a level rate of production.

Skill and experience must be taken into consideration also when evaluating the efficiency of a programmer. A new programmer may require an excessive amount of time and may encounter considerable difficulty during his early attempts at writing programs. These programs may require extensive desk checking and machine testing before they can be executed successfully. Eventually, he will have been at the job of writing programs long enough so that his efficiency can be measured against what is expected of him. If he measures up to expectations, he may be considered a qualified programmer. On the other hand, if he does not have what it takes to be a programmer, it may be better to reassign him to other duties more in keeping with his capabilities.

PROGRAM MAINTENANCE

Program maintenance should be a matter of concern to everyone associated with it. Once a program is successfully converted to the data processing system it is subject to change. Experience has proved the need for and value of making periodic changes to a program after it is in operation. Some of the more common reasons for making program changes can be attributed to many such things as:

- Additional output needs
- Desire for I/O format changes

- Normal changes—such as new or obsolete requirements
- Changes in ADP equipment, new or improved programming techniques, change in auxiliary equipment, etc.
- Changes in the scope of application
- Realization that some aspects of a program's results are not acceptable
- Unrealistic input requirement
- Misunderstandings regarding the output requirements of the program
- A possible or unforeseen condition or occurrence

Once a program is released for production after final review and found acceptable under operating conditions, it must be completely documented as to:

- Flowcharts
- Program listings
- Job specifications
- Operating procedures
- Halt listings, et cetera

Once these areas are covered, the original programmer should be relieved of most of the responsibilities of the program, so that he may work on another program. Since it is possible the original programmer may be transferred before a program is completed, all programs should be maintained by a predetermined section or division. Where major changes to a program are required, the original programmer, if available, may be called on for assistance.

The need for keeping documentation current is essential. Procedures must be established to ensure that changes made to programs are immediately and completely documented.

The section or division charged with program maintenance should maintain also a master copy of each run manual. This master copy has a twofold purpose:

1. To prevent loss or destruction of program instructions.
2. To facilitate the preparation of new run manuals in the machine room when they become dirty and/or torn.

MAINTENANCE OF EQUIPMENT

Although the increase in purchased ADP equipment has aroused considerable interest regarding ADP equipment maintenance, it is fundamental that whether the equipment is leased or purchased, the user must be assured of its reliable operation. Consequently, the data processing manager must devote special attention to scheduled and unscheduled maintenance to assure uninterrupted flow of products to the customers. Also, continued review of maintenance can avoid unnecessary data processing equipment costs.

The following common maintenance classifications and definitions are used:

- REMEDIAL MAINTENANCE (RM)—Maintenance performed by the technician (contractor or Government) which results from equipment failure and which is performed as required, and, therefore, on an unscheduled basis.
- PREVENTIVE MAINTENANCE (PM).—Maintenance performed by the technician (contractor or Government) which is designed to keep the equipment in proper operating condition and which is performed on a scheduled basis.

Close liaison with the vendor's local representative on maintenance matters is encouraged. The vendor is required, contractually, to keep the equipment in first class operating condition. It is, therefore, mandatory that there is a complete understanding on all equipment maintenance matters between the installation and the vendor's representative.

Local management must be thoroughly knowledgeable concerning all terms and conditions of pertinent contracts. In the maintenance areas, as in all others, these terms and conditions must be applied with care to ensure that the best interests of the Navy are served.

The Navy in recent years expanded its potential to maintain ADP equipment with its own personnel, namely for that ADP equipment being employed aboard ships, remote locations, and security. When in-house maintenance capability is employed, the scope of the data processing managers responsibility will increase. It will entail, in addition to the surveillance described in the following paragraphs, control of in-house personnel, optimum employment of available in-house capability, increased attention to technical data, part breakdown and reasons for failure, including but not limited to such factors as faulty maintenance, lack of preventive maintenance, etc. The manager's attention should also be focused on such items as stock levels, replenishment of peculiar parts through vendor distributors, and the host of problems associated with in-house supplies.

PREVENTIVE MAINTENANCE (PM)

Whether equipment is leased or purchased, preventive maintenance is an important tool in maximizing the potential "uptime." Vendors generally provide that degree of PM required to maintain the equipment in good operating condition. When "uptime" is satisfactory there is a dangerous tendency toward neglecting or by-passing otherwise carefully adhered to PM schedules. If malfunctions increase, the first item to be reviewed for adequacy is PM. Situations might arise which dictate variations from established PM schedules, but it is mutually advantageous to the Navy and the vendor to perform PM on a regular schedule. PM schedules must adhere to Navy policy, which limits such maintenance to hours which do not interfere with scheduled operations. In cases where special circumstances permit maintenance during working hours without interruption to operations, such maintenance can be allowed, but should not be construed as a precedent nor as a permanent arrangement.

The specific amount of PM time will not be the same for all installations. Equipment make and model, configuration, operational use time, physical environment and extended periods of RM time are some of the variables which will influence PM requirements. It is important to exercise good judgement to insure adequate PM. It would be imprudent, for example, to schedule excessive PM in an effort to eliminate all remedial maintenance. An increase in PM does not necessarily produce a corresponding decrease in remedial maintenance.

REMEDIAL MAINTENANCE (RM)

RM is that maintenance performed by technical personnel to diagnose and correct machine malfunctions. As stated, an increase in RM calls for an immediate analysis and a review of the PM program to determine if it should be adjusted. RM, however, is not completely dependent on PM. The age of the equipment and its usage play an important role in the frequency of breakdowns. Mechanical and electromechanical components are more prone to failure than electronic equipment.

EMERGENCY BACKUP PROCEDURES

Great strides have been made in improving the reliability of hardware and reducing downtime. When a computer breaks down it is usually assumed that it will not be for long. In spite of the progress that has been made, the possibility of a prolonged breakdown during a critical period does exist.

An organization may be extremely dependent on the ADP system and a breakdown of the computer could paralyze the whole operation. Provision for backing up the system should be tailored to the specific installation needs. In general, the backup procedure need not be elaborate. These procedures may consist of working arrangements with another installation having a compatible ADP system. In some cases an alternative manual procedure may be the answer. An additional possibility would be to perform only partial processing while the system is inoperative and catch up when the system again becomes operational. In the event of a total breakdown in equipment consideration must be given to the following:

- Where is the nearest duplicate system?
- How does it differ?
- Is it available?

If the maintenance technicians cannot find the problem, work stacks up, the situation becomes more and more critical, and by the time the decision is made to seek another computer the situation may be approaching the panic stage. Included in the plans for the backup procedure should be a time element for delay—that is, the plans should specify how long the system can be inoperative before the procedure is implemented.

Emergency conditions requiring planning action include local disasters such as a fire, explosion, flooding, or a similar catastrophe.

FIRE PROTECTION AND PREVENTION

In addition to planning for emergencies of varying degree, the ADP manager is responsible for the safety of personnel and the protection of equipment. An ADP system should be housed in a fire-resistant building or in a space cut off by approved, automatic-closing doors at all fire wall openings. The area should be protected against the entrance of water from any nearby sprinkler system by curbing, sills, and an overhead watertight slab. All flooring, partitions, and overhead arrangements should be of noncombustible construction. If the use of wood for flooring cannot be avoided, only lumber which has been treated by the Underwriters' Laboratories listed fire-retarded materials should be used.

The possibility of fire around electrical and electronic equipment is an ever-present hazard. It is essential, therefore, that files of punched cards and magnetic tape be safeguarded to the utmost practicable extent and that adequate measures be taken to ensure personnel safety. Carbon paper and other waste should not be permitted to accumulate in the operating area.

To protect against possible damage caused by fire, it is essential to ensure that:

- Fire bills are posted in conspicuous places within the installation.
- CO_2-type fire extinguishers are provided in the spaces occupied by data processing equipment, together with detailed instructions for their use.
- Personnel are properly instructed as to emergency action to be taken in case of fire, with due regard for preservation of card files and magnetic tape.
- A master switch is provided in the vicinity of the computer console which may be used to disconnect the power supply to computer equipment and air-conditioning equipment upon detection of fire.
- A separate library location, comparatively remote from the computer room, is provided for storage of duplicate program tapes, history files, and emergency requirements data.
- Where feasible, access to the tape storage area is possible from two directions to better facilitate emergency removal of magnetic tapes.
- The local fire fighting activity must be informed that burning plastic tape and containers creates a toxic effect and that any fire would possibly be electrical in nature.
- Good housekeeping practices in regard to fire hazards are enforced.

ADP MANAGEMENT CHECKLIST

Each manager in an ADP installation should conduct a constant review and analysis of the functions for which he is responsible. The following checklist is provided as a guide for examining the areas in which you may be able to contribute improvements which raise the operating standards of your installation.

ORGANIZATION, MANNING, AND TRAINING

Do you, as a manager, know exactly what is expected of you? Your answer takes into account these questions:

- Does the organizational chart reflect actual operations?
- Are you thoroughly familiar with all jobs for which you are responsible?
- Do you maintain manuals of procedure containing all items necessary for exercising control?
- Are manning requirements subjected to periodic review?
- Is optimum advantage taken of available training opportunities to enable personnel to upgrade skills and abilities?
- Is information on hand and available to all personnel on ADP technical training courses, professional development opportunities, and executive orientation programs?
- Are ADP occupational specialties reviewed to determine balance, currency, and best mix for accomplishing the mission?

OPERATING PROCEDURES

Are pertinent regulations, manuals, and operating instructions current and accessible? Are operating instructions adequate as to coverage and format? By extension, these questions can be asked:

- Are computer systems and programs adequately documented and standard in manner?
- Are operating instructions used by computer console and EAM operators?
- Do you refer to the operator's instructions to analyze and determine ways in which procedures and methods can be improved?
- Have recent program changes been posted to both procedure files and run-books?

WORKLOADS

Have you made a careful determination of machine and clerical workloads? Your answer depends on how you answer these questions:

- Are records maintained which reflect the time required for clerical functions under your span of control?

- Do you keep production records of keypunch and verifying operations which show speeds in columns per hour and the percentage of errors?
- Do you determine processing time by using known machine speeds and workloads?
- Is there a procedure for conducting a periodic review of local recurring reports and output products?
- Are procedures established to keep extra use time to a minimum?

SCHEDULING

Are all your job requirements scheduled? Before you answer, consider these questions:

- Are definite due-in and due-out dates set up for each job?
- Has sufficient processing time been allowed for producing accurate results?
- Are jobs scheduled in accordance with their priority?
- Have work schedules been so organized that they can be analyzed and adjusted as necessitated by changing requirements?
- Does the system indicate when equipment is available for use?
- Is there a job staging system so that tapes, files, operator instructions, and programs are positioned?
- Ascertain scope of coverage of production scheduling, i.e., are all workloads—EAM, EDP, keypunch, decollating, etc., considered in the schedule?
- Are analyses made which include comparisons of input receipt date to due-in date, job completion date to due-out date, job time standard to production time?
- Is there complete cooperation among supervisors in coordinating the work flow throughout your installation?

CONTROLS

Have you provided for adequate control of your assigned operations? Controls are adequate if you can answer YES to the following questions:

- Are all source documents controlled and accounted for while in your custody?
- Do the operating procedures contain sufficient accounting controls and checkpoints to assure accuracy of results?
- Have you provided controls for detecting and isolating possible errors, and for recreating any transaction without the aid of memory?
- Have you established audit trails through control totals, registers, and reference data?
- Are you sure your system of controls is being adhered to in accordance with established procedures?

CARDS, TAPE, AND SUPPLIES

Have you instructed your operators to handle cards as precise, accurate, accounting tools? Are you satisfied that your personnel handle magnetic tapes as a precision engineered product? To these questions add also these:

- Does the tape library control system provide tape location capability during storage or operation? Is the control over returns of tape, either from operations or remote shipment, adequate?
- Is the size of the tape inventory reasonable in each category (manager hold, cyclic hold, current, scratch, unserviceable, etc.)?
- Is there a requirement for a tape cleaner?
- Is the tape certification, cleaning, or degaussing equipment adequate to handle the tape inventory? Is utilization sufficient to warrant retention?
- Does the tape storage facility provide adequate environmental conditions, space, reel storage, and access control?
- Are cards being kept under pressure in a file when not being used?
- Are control procedures adequate to ensure that Navy-wide stock availability/GSA availability is considered prior to initiation of procurement of supply consumption items?

OPERATIONS AND OTHER MANAGEMENT ITEMS

Do you conduct reviews with major users to determine customer satisfaction with all aspects of service (guidance, product adequacy, accuracy, timeliness, equipment maintenance, etc.)? Reviews would include a search for answers to these questions:

- Are programming problems reported, documented, and resolved in accordance with existing directives?
- Do adequate procedures exist for review and approval/disapproval of locally generated requirements for data?
- Do you review and evaluate equipment justifications for individual machines showing low utilization?
- Is there a plan for continuity of ADP operations under emergency conditions? Are the plans up to date?
- Are critical files selected for backup storage and are file reconstruction procedures and backup data available to ensure minimum disruption of ADP operations in the event of emergency or local disaster?
- Is there adequate documentation of fire protection and emergency fire procedures?
- Does a review of maintenance response time on remedial maintenance calls indicate adequate support? Has maintenance action been timely and satisfactory?
- Do you cooperate with maintenance personnel in setting up inspection schedules and instructing operators in the proper care of equipment?
- Are all personnel briefed on security regulations, and does the unit have adequate security control?
- Are clear-memory procedures documented and understood by operator personnel?

LEADERSHIP

Do you display those traits which identify you as a leader of people? If you do, your answer is YES to these questions:

- Are you completely familiar with the capabilities of all your personnel?
- Do you make effective use of the supervisory abilities of personnel under your control by delegating certain supervisory functions to them?
- Do you show your appreciation of the value of good morale by providing good working conditions, being a fair and impartial supervisor, and by gaining respect as a leader?
- Are you afforded a sufficient amount of leeway to manage your installation in the way you see fit and yet produce satisfactory results?

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